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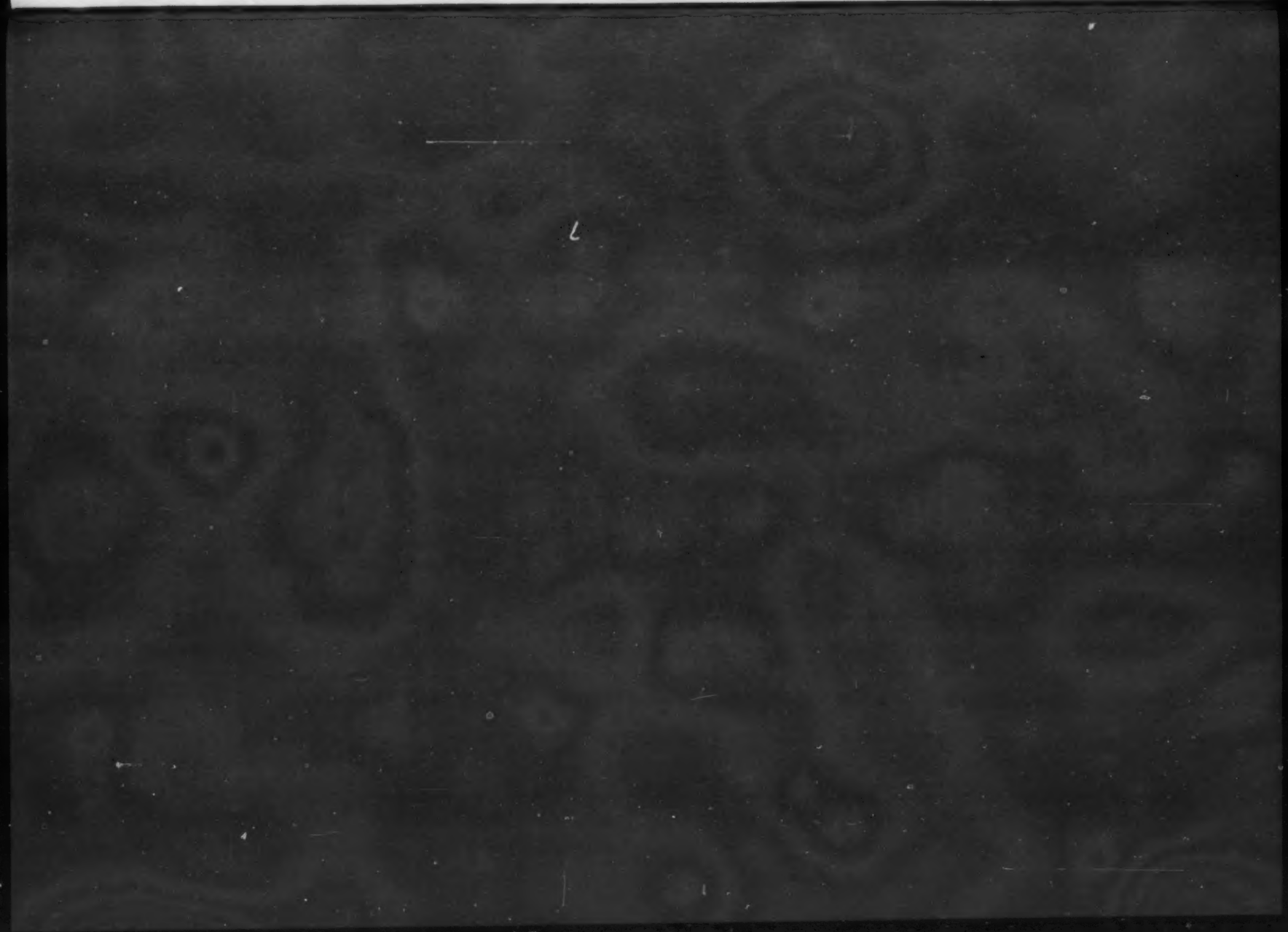
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service



RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 6 June 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

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CONTENTS

REPORTS

Page

Colorado Dental X-ray Machine Survey, 1961–April 1965 -- 319
R. W. Alcox, R. A. Downs, and *P. W. Jacoe*

Radioactivity in Milk in the United Kingdom, 1962–1965 -- 326
R. S. Bruce

Radionuclides in the United Kingdom Diet, 1962–1964 ---- 331
R. S. Bruce

DATA

SECTION I. MILK AND FOOD ---------- 335

National and International Milk Surveillance ---------- 336

(including list of other programs previously reported)

1. Pasteurized Milk Network, February 1966, *PHS* ---- 336
2. Canadian Milk Network, February 1966 ---------- 339
3. Pan American Milk Sampling Program, February 1966, *PAHO* and *PHS* ---------- 340
4. Radiostrontium in Milk, July–December 1965, *AEC* -- 340

State Milk Surveillance Activities ---------- 343

(including list of other State programs previously reported)

1. California Milk Network, October–December 1965 and Annual Summaries 1964 and 1965 ---------- 344
2. Oregon Milk Network, October–December and Annual Summary 1965 ---------- 345
3. Washington Milk Network, October–December and Annual Summaries, 1964 and 1965 ---------- 347

CONTENTS—continued

Page

Food and Diet Surveillance Activities 349

(including list of programs previously reported)

1. Strontium-90 in Tri-City Diets, August–October 1965 349

2. Estimated Daily Intake of Radionuclides in California Diets, May–August 1965 351

SECTION II. WATER 353

(including list of programs previously reported)

Gross Radioactivity, December 1965, and Strontium-90, April–September 1965, in Surface Waters of the United States, *FWPCA* 354

Radioactivity in New York Surface Water, June–December 1965 359

Radiostrontium in Tap Water, May and July–November 1965, *AEC* 361

SECTION III. AIR AND DEPOSITION 363

Radioactivity in Airborne Particulates and Precipitation

(including list of programs previously reported) 364

1. Radiation Surveillance Network, February 1966, *PHS* 364

2. Canadian Air and Precipitation Monitoring Program, February 1966 367

3. Pan American Air Sampling Program, February 1966, *PAHO* and *PHS* 368

SECTION IV. OTHER DATA 370

Strontium-90 in Human Bone, First Quarter 1965, *PHS* .. 370

Environmental Levels of Radioactivity at Atomic Energy Commission Installations 372

1. Brookhaven National Laboratory, July–December 1965 373

2. Rocky Flats Plant, July–December 1965 374

SECTION V. TECHNICAL NOTES 376

Reported Nuclear Detonations, May 1966 376

Synopses iii

Symbols, Units, and Equivalents ..... Inside back cover

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Dr. Donald R. Chadwick, Chief, and
James G. Terrill, Deputy Chief
Division of Radiological Health

by the Radiation Surveillance Center, DRH
Donald L. Snow, Chief

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Address correspondence to the Managing Editor, Radiation Surveillance Center, Division of Radiological Health, Public Health Service, Washington, D.C. 20201.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

COLORADO DENTAL X-RAY MACHINE SURVEY, 1961–APRIL 1965

R. W. Alcox,[1] *R. A. Downs,*[2] *and P. W. Jacoe*[2]

SYNOPSIS — Results of a two-phase program for examining dental X-ray machines showed marked progress by the dental profession in correcting equipment and procedural deficiencies identified by mail-order surveys and physical surveys conducted by the Colorado State Department of Public Health. The first phase of the program was a "Surpak" mail-order survey and the second phase was a physical survey using standards recommended by the U.S. Public Health Service for X-ray beam diameters, filtration of the primary beam, beam definition, and leakage. Following the first phase of the study, the number of machines having beam diameters of 2.75 inches or less increased from 48 to 73 percent; following modifications during the physical survey phase, 85 percent of the machines met the standards. Improvement in meeting filtration standards is shown in a rise from 25 percent compliance during the first survey to 74 percent. During the physical surveys, many areas of dental radiographic practice were examined and specific changes were made or recommended to minimize exposure to both patients and dental personnel. The most common procedural errors observed were overexposure and inadequate development of film.

As a part of the overall program to assure the safe and effective use of X-ray machines in Colorado, the Colorado State Department of Public Health, in cooperation with the Colorado Dental Association and with local health departments, has conducted a two-phase program to identify and correct possible public health hazards arising from the improper use of dental X-rays in the State. This report presents the findings of the program for the period 1961–April 1965.

The initial phase of the dental radiological health program was a mail-order survey for identifying several of the most important factors that contribute to unnecessary radiation exposure from dental X-ray equipment. For this purpose dentists were supplied with a specially prepared film kit known as the Surpak (*1*). This kind of survey can be made with a minimium of highly trained personnel.

The second phase and a continuing activity of the State dental radiological health program consists of mandatory registration and voluntary physical survey inspection of the dental X-ray equipment used in the State. Thus far, 643 X-ray units have been inspected by the Surpak method and 764 units have been inspected by the physical survey method. Physical surveys are comprehensive and exhaustive inspections requiring the services of trained radiation personnel, equipped with suitable instruments to measure the radiation output of the equipment and demonstrate scatter radiation to the practitioner. The physical survey involves the investigation of the many facets of dental radiographic practice that may contribute unneces-

[1] Dr. Alcox is chief, Dental X-ray Program, State Assistance Branch, Division of Radiological Health, U.S. Public Health Service, Rockville, Maryland.

[2] Dr. Downs is director, Division of Special Health Services; Mr. Jacoe is chief, Radiological Health Section of the Division of Occupational and Radiological Health, Colorado State Department of Public Health, Denver, Colorado.

sary radiation exposure to both dental personnel and their patients. During the survey an opportunity is provided to install corrective devices "on the spot" for many practitioners. The surveyor, by measuring radiation levels in various locations, can also assist in selecting a location so as to minimize exposure to the dentist and his personnel during X-ray procedures.

Beam diameter and filtration standards

The State of Colorado has adopted the beam diameter and filtration standards recommended by the U.S. Public Health Service (*2*). These standards require that beam diameters should be 2.75 inches at the tip of the cone and shall not exceed 3.0 inches. The recommended amount of filtration is 2 mm total aluminum equivalent for equipment operating below 70 kVp and 2.5 mm above 70 kVp. The other recommendations adopted by the State Health Department are based on those of the Radiation Protection Committee of the American Academy of Oral Roentgenology (*3*), and the National Council on Radiation Protection and Measurements (*4*).

The purpose in collimating or restricting the diameter of the X-ray beam to 2.75 inches at the tip of the pointer cone is to limit the exposure to the area of diagnostic concern. Large beams needlessly irradiate structures such as the lens of the eye, the thyroid gland, and contiguous structures in the neck and head, while contributing nothing of diagnostic value to the radiograph. Radiation of the lens of the eye and the thyroid gland may be a contributing factor to cataractogenesis and thyroid tumorigenesis(*5*). Collimation of the primary beam to the area of diagnostic concern also leads to better defined radiographs by diminishing backscatter radiation.

Filtration of the primary X-ray beam reduces the low energy portion of the X-ray beam ("soft X-rays") which do not have sufficient penetrating ability to reach the film. These portions of the X-ray beam would otherwise be absorbed by the patient and contribute nothing to the radiograph. Total filtration is composed of "inherent" and "added" filtration. Inherent filtration is that filtration already present due to the structural elements of the tube head; added filtration is that additional filter material (usually aluminum) which brings the total filtration up to the recommended values.

Initial survey

In 1961, the use of the dental Surpak was introduced into the State through the cooperative efforts of the Colorado Dental Association, the Colorado State Department of Public Health, local health agencies, and the Public Health Service. Specially prepared 8- by 10-inch X-ray film packs (Surpaks) were mailed to participating dentists. The films were exposed according to directions printed on the outside of the Surpak and were mailed to the Colorado State Department of Public Health. Accumulated Surpak films were shipped periodically to the Public Health Service Radiological Health Laboratory in Rockville, Maryland, for processing and analysis of data. The Surpak provided information on filtration, beam diameter, beam symmetry, beam definition, and leakage in the anterior direction. This information was returned to the State or local health department, which in turn informed the dentist as to whether or not his equipment met the recommended standards. If the equipment did not meet the recommended standards, the dentist was so advised and urged to make the necessary modifications of his equipment.

Physical survey program

The Colorado Department of Public Health began a program in 1963 to register the X-ray machines throughout the State. Since that time, the State or local health departments have offered the services of radiological health specialists to survey registered machines. Where a local health department exists, its personnel assist in the survey of X-ray equipment installations. In other areas of the State, the surveys are performed directly by State Health Department personnel. All survey data are treated as confidential information; individuals are not identified in statistical analyses or reports.

Health department personnel gather and record information on each machine's characteristics and discuss findings on the spot with

the machine operator. When possible, collimators and filters are provided as a service. Where indicated on the basis of survey findings, suggestions are offered to the operating personnel to enable them to reduce unnecessary radiation exposure to their patients and themselves. Followup letters to the dentist summarize findings and repeat suggestions.

The data obtained are sent to the PHS Radiological Health Laboratory, which provides compilation, processing, and analytical services to the State Health Department.

Physical survey procedures

During the physical inspection, health department personnel check each machine for filtration by noting (1) the added filtration and the inherent filtration listed by the manufacturer; (2) the beam diameter, with a fluorescent screen; (3) the roentgen output, using a Victoreen r-meter both before and after filtration has been added; and (4) other important factors including cord length, timer control, pointer cone, and tube head stability. A number of operational questions are asked, including the number of films taken per week, average exposure time, use of protective barriers and leaded aprons, personnel monitoring, type of film used, development time, development temperature, and interval between development solution changes. The third area of inspection is the operating position of the dentist and/or assistant. Rice bags, 5 inches in diameter and 8 inches tall, are used as a phantom to scatter the radiation in a manner similar to a patient's head. Measurements with a "Cutie Pie" survey meter are taken where the X-ray personnel stand for right and left bitewing exposures and the upper anterior periapical exposure. Based on these measurements, positions affording the lowest exposure rate to operating personnel are selected and recommended to the operators.

Beam diameter

The Surpak survey showed only 48 percent of the machines tested had a beam diameter of 2.75 inches or less. During the subsequent physical survey, it was found that 73 percent of the machines tested had beam diameters of 2.75 inches or less, indicating that the Surpak survey had stimulated corrective action. After the physical survey, 85 percent of the machines had beam diameters of 2.75 inches or less, even though some machines could not be corrected because either the pointer cone could not be removed or a special size collimator was needed.

Filtration

The Public Health Service recommendations (*2*) for filtration are used in the survey. Where the total filtration was less than the accepted recommendations, additional filtration was supplied by the survey team. Figure 1 shows the amount of total filtration before and after modification. Substantial improvement in filtration can be noted by comparing the "before" and "after" portions of the graph. Some machines which needed additional filtration could not be corrected because either the pointer cone could not be removed or a special size filter was needed.

The exposure rate at the end of the pointer cone was 1 roentgen per second or less in 49 percent of machines before modifications and in 71 percent of machines after modifications, indicating a reduction in exposure rate due to the filtration added during the survey.

Other physical characteristics

The findings of the physical survey, with respect to the type of timer used, showed that slightly more than half of the dental X-ray units have a mechanical timer, while the remainder use electronic timers. The survey also showed that 86 percent of the units had control cables which permitted the operator to stand at least 6 feet from the tube head, and that 95 percent of the X-ray machines inspected had adequate tube head stability.

Table 1 shows the percentage distribution of pointer cone types in use. Comparison with national figures indicates that the use of a long open cone is reported by a greater percentage of

Table 1. Distribution of pointer cone types in use

Type of cone	Percent
Short pointed	69.0
Short open	5.4
Long pointed	11.3
Long open	12.8
None	0.4
Not stated	1.0

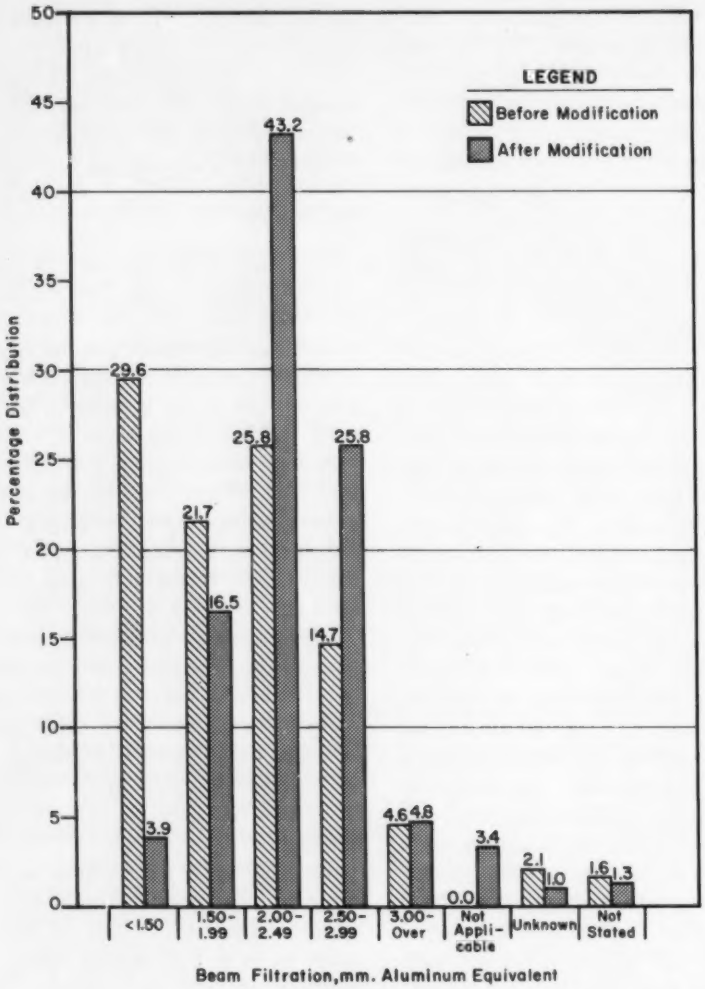

Figure 1. Percentage distribution by beam filtration, before and after modification

dentists in Colorado than in the rest of the United States. The use of an open cone is recommended, since the least amount of scatter radiation results from this type of cone.

Leakage radiation was detected in only 2.9 percent of the X-ray units inspected.

Film speed used

Table 2 shows the speed groups of X-ray film used. Each film speed is designated by the reciprocal of the exposure in roentgens required to produce a density of 1.0 under set conditions (*6*). Thus, low speed films have low numbers and the fast speed films have high numbers. The decrease in radiation exposure, when going from group "B" to group "D", can be up to eightfold. Therefore, it is evident that the use

Table 2. Type of film used

Speed group	Speed range in reciprocal roentgens	Percent distribution
B	3.0— 6.0	18.5
C	6.0—12.0	18.5
D	12.0—24.0	53.1
Not stated	Not stated	9.9

of the high-speed films permits specific reductions in unnecessary exposure to patients and personnel.

Exposure and development procedures

In many instances, the exposure and development procedures were faulty. The most common procedural errors were long exposure time and a short development time. Such practices of overexposure and underdevelopment of film increases the unnecessary radiation exposure to both patients and personnel.

The percentage distribution of development time by film speed is shown in figure 2. The greatest percentage of dentists develops film for 2.5 to 3 minutes, rather than a more optimal 5 minutes. Many dentists estimated the reported developing time using the "sight" method instead of a timer. This involves checking the film by sight against a safelight during development until a suitable radiograph is obtained. This practice often leads to overexposing and underdeveloping.

The development temperature was reported to be 68° to 70°F. by 73 percent of the participants. This is an optimal temperature. Fifty-one percent of the dentists reported that they changed their developing solutions every 4 weeks. The next most common intervals were 8, 2, and 6 weeks (11, 10, and 9 percent, respectively). The developing solutions should be changed at least every 4 weeks as they deteriorate more from oxidation and exposure to air than they do from the workload encountered in the average dental office.

Exposure to patients and personnel

The reduction of radiation exposure to the operating personnel as well as the patients was of primary importance during the survey. To obtain exposure figures on operating personnel, readings were taken at normal operating positions, and at other possible operating positions, until the position of minimal exposure was found. In addition, the presence of protective

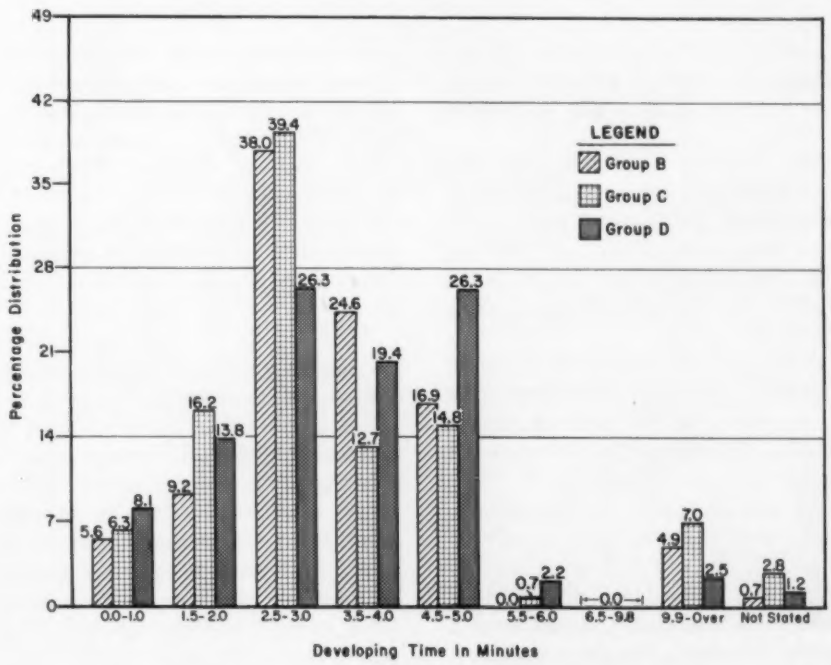

Figure 2. Percentage distribution by developing time for film speeds

Table 3. Percentage distribution of dentists' occupational exposure in mR per hour for old and new positions

Occupational exposure	Left bitewing exposure		Anterior periapical exposure		Right bitewing exposure	
	Old position	New position	Old position	New position	Old position	New position
0–19	25.3	56.9	24.6	58.0	26.8	57.1
20–49	12.6	4.4	10.2	4.0	10.8	4.7
50–99	12.1	2.0	12.8	3.4	16.5	2.0
100–999	36.1	2.7	40.0	2.5	33.6	2.3
1,000–3,499	2.9	0.0	2.7	0.0	2.2	0.0
3,500–5,999	0.3	0.0	0.0	0.0	0.0	0.0
Not applicable [a]	0.1	1.4	0.0	1.6	0.1	2.3
Unknown or not stated	10.6	32.6	9.7	30.5	10.0	31.6

[a] Dentists' technique and operating procedures are such that no modifications are necessary.

Table 4. Percentage distribution of assistants' occupational exposure in mR per hour for old and new positions

Occupational exposure	Left bitewing exposure		Anterior periapical exposure		Right bitewing exposure	
	Old position	New position	Old position	New position	Old position	New position
0–19	31.8	41.3	32.3	42.4	33.6	41.5
20–49	9.7	3.3	9.0	2.3	7.7	4.2
50–99	7.6	0.9	9.5	1.6	8.3	1.0
100–999	17.7	1.6	16.7	0.9	17.2	0.9
1,000–3,499	1.6	0.0	1.2	0.0	1.1	0.0
3,500–5,999	0.1	0.0	0.0	0.0	0.0	0.0
Not applicable [a]	9.0	11.6	8.9	11.6	9.0	12.0
Not stated	22.5	41.3	22.4	41.2	23.1	40.4

[a] Dentists' technique and operating procedures are such that no modifications are necessary.

barriers, the use of leaded aprons for the patient and operator, the type of personnel monitoring, and the number of films per week were noted.

Tables 3 and 4 show the exposure in mR/hr to dentists and assistants at old positions and at new recommended positions. These tables show the great reduction of occupational exposure that can be achieved by utilizing the positions identified by the surveyors in their inspections.

A protective barrier of some sort was used by 64 percent of the operators reporting. This indicates an awareness of the value of shielding. Interestingly, 76 percent of the dentists did not use leaded aprons in any way.

The majority (78 percent) of dentists reported that they were using no type of personnel monitoring. Six percent indicated the use of a commercial film badge service. Thirteen percent indicated the use of dental film with a coin or paper clip attached; this is of questionable value because of the lack of quantitative information.

The percentage distribution of the number of films exposed per week (figure 3) reveals that the dentists in Colorado expose approximately the same number of films per week as the rest of the national average. Fifty-nine percent of the offices surveyed exposed 50 or fewer films per week; 75 percent exposed 75 or fewer films per week; and 85 percent exposed fewer than 100 films per week.

Results

Selected results of the Surpak and physical surveys are summarized in table 5. It is interesting to note that in many cases the beam diameters and filtration were corrected between the time of the Surpak survey and the physical survey. Obviously, the Surpak survey phase pointed out machines needing correction. The dental profession in Colorado is to be congratulated on its promptness in making indicated corrections. The findings of this study clearly demonstrate the value of the Surpak survey. The effectiveness of the physical survey phase is shown in the last two columns of the table.

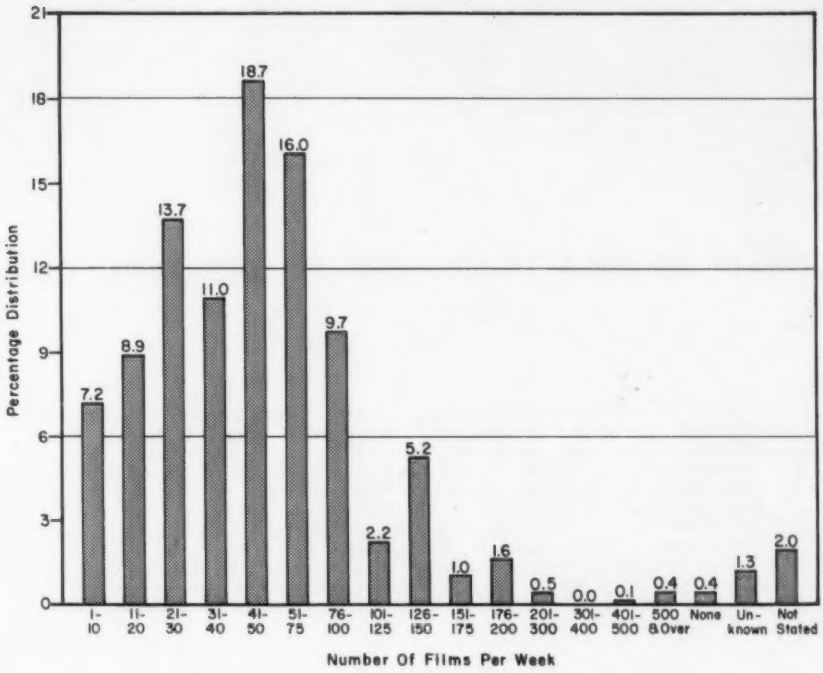

Figure 3. Percentage distribution by number of films per week

Table 5. Results of Surpak and physical surveys

Findings	Surpak survey (percent)	Physical survey	
		Percent before modification	Percent after modification
Beam diameter 2.75 inches or less	48	73	85
Beam diameter 3.0 inches or less	69	78	90
Filtration ≥2 mm aluminum equivalent	25	46	74
Long pointer cone	22	24	24
Good beam symmetry	95		
No anterior leakage	97		
Acceptable beam definition [a]	90		

[a] Beam definition is considered acceptable when the Surpak film exhibits a well-defined exposure area with little or no scattered radiation.

Corrections made as a result of this survey resulted in a reduction in potential patient and operator exposure.

Comparison with national figures for collimation and filtration indicates that data for X-ray machines in Colorado were nearly the same as those for X-ray machines in the United States as a whole (*7*).

Acknowledgements

The cooperation of the Colorado dental profession in making these surveys possible is gratefully acknowledged.

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RADIOACTIVITY IN MILK IN THE UNITED KINGDOM, 1962–1965

R. S. Bruce [1]

SYNOPSIS—Radiochemical analyses of raw milk produced in the United Kingdom showed that in 1962 the total iodine-131 in milk was about 85 percent of that found in the autumn of 1961; subsequently, levels have remained below the limit of detection. Concentrations of strontium–90 and cesium–137 increased sharply in 1962 and again in 1963, reaching maximum levels in the middle of the year. Since then, apart from seasonal fluctuations, there has been a general decrease in contamination. The annual average ratio of strontium–90 to calcium in milk in the United Kingdom increased from 5.9 pCi/g in 1961 to 28 pCi/g in 1964, and fell to 19 pCi/g in 1965. The mean concentration of cesium–137 changed similarly, the values for 1964 and 1965 being, respectively, 153 and 98 pCi/liter.

Since 1958, the Agricultural Research Council Radiobiological Laboratory has performed radiochemical analyses of raw milk produced in the United Kingdom. For the "countrywide" survey, until the end of 1964, raw milk was collected from over 200 depots which together handled about 40 percent of the country's production. Figure 1 shows the sources of the milk samples and the boundaries of the zones. The principles on which the depots were selected have already been described (*1*). In 1965, the plan of the survey was revised (*2*) and the number of depots reduced to 82, which handled 28 percent of the total production in the United Kingdom. The number of zones in England was also reduced from 7 to 4 by combining three pairs of adjacent zones. Samples, representative of the total milk received from farms, are collected on 2 days in each month from each group of depots and bulked in proportion to the quantity of milk they handle.

[1] Agricultural Research Council Radiobiological Laboratory, England.

Iodine–131

When atmospheric nuclear testing was resumed in September 1961, arrangements were made for the routine analysis of iodine–131 in milk. In the last quarter of both 1961 and 1962, milk from the countrywide survey was analyzed at weekly intervals. In addition to the countrywide survey, samples were obtained daily from up to 23 "regular sampling points" to enable day-to-day variations to be followed more closely. Full details of the sampling programs are given in the laboratory's reports (*3,4*).

Results to the end of April 1962 have already been given (*5*); further results from the countrywide survey to the end of December 1962 are given in table 1 and trends in the concentration of iodine-131 in milk since the survey began are shown in figure 2.

From May to mid-August, very low levels of iodine–131 appeared sporadically in different parts of the country. These were never maintained for more than a few days and no iodine-131 was detected in the bulked samples from

Figure 1. Map showing sources of samples and boundaries of zones in the countrywide survey of milk

Zones: 1 Northern England; 2 North West England; 3 East and East Midlands; 4 West Midlands; 5 Wales; 6 South and South East England; 7 Mid-Western England; 8 Far Western England; 9 Scotland; 10 Northern Ireland

the countrywide survey. In late August these low levels occurred more frequently and in the first week of September a marked rise occurred. There was some decrease toward the end of September but another peak occurred at the beginning of October. During these 2 months, the weekly average values for iodine–131 in milk from the regular sampling points ranged from 20 to 87 pCi/liter and the countrywide average value from 24 to 96 pCi/liter. The iodine–131 which entered milk in this period was about two-thirds of that found at the corresponding time in 1961 during earlier weapons tests in high northern latitudes. In the last week of October the levels fell to only about twice the limit of accurate detection (11 pCi/liter), but this decrease was followed by a pronounced rise in mid-November when the weekly average values for the regular sampling points and for the countrywide survey were 143 and 176 pCi/liter, respectively. These levels were comparable with the highest found in the autumn of 1961, although similar levels were then maintained over a longer period. In some of the individual zones the increase was more marked and in Scotland the weekly bulk sample representative of production on November 12 contained 370 pCi/liter. This rapid increase in

Table 1. Iodine-131 concentrations in United Kingdom milk: results of countrywide survey, September to December 1962

Date of sampling (1962)	Iodine-131, pCi/liter										
	Zone										Country-wide mean weighted for production
	Northern England	North West England	East and East Midlands	South and South East England	West Midlands	Mid-Western England	Far Western England	Wales	Scotland	Northern Ireland	
Sept 1	—	—	—	—	—	—	—	—	—	—	25
15	114	45	50	51	44	47	74	94	87	78	65
24	71	30	43	32	29	41	30	43	66	43	42
Oct 1	88	141	62	75	84	89	95	86	103	105	96
8	98	76	69	41	71	67	76	83	111	52	75
15	37	44	34	25	37	24	43	41	53	37	38
22	46	37	14	<11	14	13	23	24	30	37	24
29	66	30	33	36	33	60	65	53	61	60	47
Nov 5	52	28	15	44	39	60	53	48	47	22	41
12	248	140	158	78	146	138	153	186	370	204	176
19	82	89	105	85	87	149	157	149	125	172	115
26	46	46	57	61	57	72	178	67	44	86	66
Dec 3	27	29	58	43	30	70	62	66	30	136	50
10	<11	19	<11	<11	19	12	27	22	36	52	19
17	<11	<11	33	19	12	17	28	31	23	40	19
24	<11	<11	24	<11	28	<11	27	16	<11	<11	<11
31	27	<11	<11	<11	18	<11	<11	31	<11	15	<11

levels was followed by a rapid decline and by early December the average level was about 50 pCi/liter. Later in that month the severe weather, which covered pastures in many parts of the country with snow, hastened the decrease. Since January 1963 the concentrations of iodine–131 in milk have remained below the limit of detection.

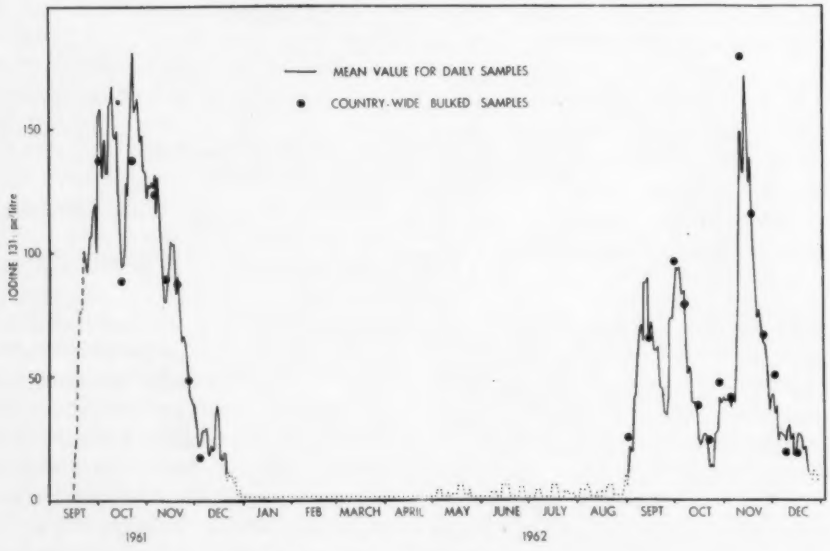

Figure 2. Iodine–131 in milk: Average daily values for regular sampling points, September 1961 to December 1962. The country-wide mean values are also shown.

Values for early September 1961 are shown by a broken line, as sampling was then limited. A dotted line is used when values were below the limit of accurate detection (11 pCi/liter)

Strontium–90

From 1962 to 1965 samples of milk from the individual zones of the countrywide survey were bulked and analyzed for strontium–90 at either 6-week or quarterly intervals.

Results for 1961 were reported earlier (*5*) and detailed results for subsequent years appear in the Laboratory's reports (*2,4,6*). Annual mean results, expressed as ratios of strontium–90 to calcium, for the individual zones of the countrywide survey from 1962 to 1965, are given in table 2. Trends for the countrywide mean ratio from 1958 to 1965 are shown in figure 3; the estimated average deposition of strontium–90 in the United Kingdom is also shown for comparison.

The concentrations of strontium–90 in milk rose sharply in the late spring of 1962, reaching a maximum in August and then decreasing to rather lower levels later in the year. In 1963 the substantial increase in the rate of fallout due to the combined effects of the nuclear tests in 1961 and 1962 caused the countrywide average ratio of strontium–90 to calcium to increase by a factor of 3.5 between March and August when the contamination of milk reached the highest levels since the survey began. Since then, apart from seasonal fluctuations, there has been a steady decline in the concentrations of strontium–90; and at the end of 1965 they were lower than at any time since early in 1963.

Table 2. Countrywide survey in milk in the United Kingdom: annual mean ratios of strontium-90 to calcium 1962–1965

Zone	Mean ratio: $^{90}Sr/Ca$, pCi/g			
	1962	1963	1964	1965
Northern England	11.6	25.8	30.7	18.1
North West England	9.5	20.5	22.0	
East and East Midlands	7.2	15.8	16.6	13.0
South and South East England	8.0	20.2	21.1	
West Midlands	10.0	19.3	20.2	14.6
Mid-Western England	9.5	22.4	27.8	
Far Western England	17.5	39.5	36.6	24.3
Wales	16.3	35.4	41.7	26.5
Scotland	16.8	33.4	36.7	26.3
Northern Ireland	16.4	38.1	39.2	26.8
Countrywide mean weighted for production	11.7	25.6	28.0	19.0

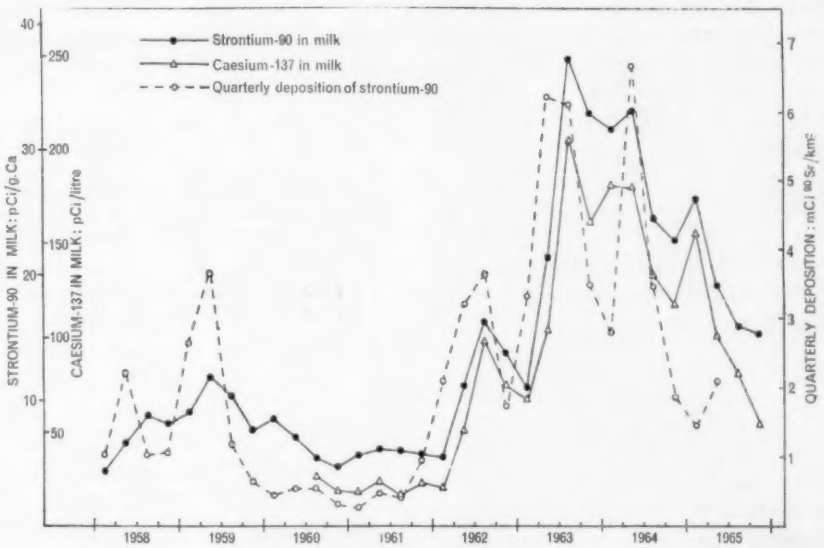

Figure 3. The countrywide average ratio of strontium–90 to calcium and the concentration of cesium–137 in milk compared with the estimated quarterly rate of fallout

The rate of fallout is shown by the deposition of strontium–90; as the ratio of cesium–137 to strontium–90 in fallout is relatively constant, the trends for strontium–90 indicate those for cesium–137 also. The deposition of strontium–90 is calculated from the mean concentration in rain, measured quarterly at seven sites by the Atomic Energy Authority, and the average rainfall in the United Kingdom

The annual countrywide mean ratio of strontium–90 to calcium increased from 5.9 pCi/g in 1961 to 28.0 pCi/g in 1964, and then decreased by about one-third to 19.0 pCi/g in 1965. The countrywide 12-month mean was at its highest for the period July 1963 to June 1964 when the value was 34 pCi/g. In general, the results for individual zones of the survey ranged from about 0.6 to 1.5 times the countrywide average, differences between zones being attributable mainly to regional differences in rainfall.

Cesium–137

From the middle of 1960 until September 1961, cesium–137 concentrations were determined every 3 months in bulked samples of milk. With the resumption of weapons testing in September 1961, cesium–137 analyses were performed on samples from individual zones in the countrywide survey at the same intervals as for strontium–90.

The general trends for the changes in the concentrations of cesium–137 in milk were very similar to those for strontium–90 (figure 3); peak concentrations were reached in July 1963 and since then levels have declined. The annual mean concentrations from 1962 to 1965 are summarized in table 3. Countrywide means for the last 9 months of 1960 and for the whole of 1961 were, respectively, 26 pCi/liter and 21 pCi/liter. The annual mean concentration rose to 153 pCi/liter in 1964 and then decreased by one-third to 98 pCi/liter in 1965; the values for individual zones ranged from about 0.6 to 1.7 times the countrywide mean.

Table 3. Countrywide survey of milk in the United Kingdom: annual mean concentrations of cesium-137, 1962–1965

Zone	Mean concentration of cesium-137, pCi/liter			
	1962	1963	1964	1965
Northern England	67	140	171	98
North West England	51	108	130	
East and East Midlands	36	74	94	68
South and South East England	42	94	110	
West Midlands	42	90	106	74
Mid-Western England	38	93	109	
Far Western England	93	206	220	121
Wales	97	209	218	132
Scotland	85	199	205	118
Northern Ireland	110	220	263	164
Countrywide mean weighted for production	62	135	153	98

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RADIONUCLIDES IN THE UNITED KINGDOM DIET, 1962–1964

R. S. Bruce [1]

SYNOPSIS—In continuing United Kingdom diet studies, a fourfold increase in strontium–90 contamination of the average diet has been observed between 1961 and 1964. The ratio of strontium–90 to calcium in the average mixed diet in 1964 was 25.9 pCi/g (corresponding to an intake of 28.5 pCi/day), which is nearly three times the value in 1959. During 1962 to 1964, the relative contributions of strontium–90 from different types of food remain fairly constant. Cesium–137 levels increased markedly between 1961 and 1963, the estimated daily intake, based on assays of five types of food, rising from about 30 to 170 pCi/day; in 1964 the value was 160 pCi/day. Measurements of strontium–89 and barium–140 during 1962 and 1963 indicated that these nuclides were minor radioactive contaminants of the diet.

Responsibility for the investigation of the contamination of human food with radioactive substances in the United Kingdom was assigned in 1957 to the Agricultural Research Council (ARC). In 1958, when surveys of radioactivity in human diet were begun in the ARC Radiobiological Laboratory, attention was confined to strontium–90 as this is the long-lived component of worldwide fallout which delivers the highest radiation doses to man through the contamination of his food. Some measurements of the shorter-lived isotope, strontium–89, were also made but their primary purpose was to provide information on the mechanisms by which strontium–90 enters the diet. In subsequent years, the sampling network devised for strontium–90 provided a basis for measurements of iodine–131, barium–140, and cesium–137. The general principles of the survey have been described previously (*1*) and full details of sampling procedures and results are given in the Laboratory's reports (*2*).

[1] Agricultural Research Council Radiobiological Laboratory, England.

Content of strontium–90 in the average diet

The mean quantity of strontium–90 in the average mixed diet of the population in the United Kingdom has been calculated by multiplying the mean ratio of strontium–90 to calcium in different types of food by the quantities of calcium they contribute to the diet. This is illustrated by the results for 1964 which are given in table 1. Results for previous years, summarized in table 2, were calculated in a similar manner.

The countrywide survey provides the necessary information on milk, cheese, eggs, and cereals. These components provide over 80 percent of the dietary calcium which is of either animal or vegetable origin. The survey also provides information on the two most widely consumed types of vegetables, potatoes, and leafy brassicas. As plant species do not discriminate appreciably between strontium and calcium, the ratio of strontium–90 to calcium in potatoes has been taken as representative of that in all root vegetables and the ratio in leafy brassicas as representative of that in other vegetables and fruit.

Table 1. Mean content of strontium-90 in the diet in the United Kingdom, 1964

Origin	Mean daily intake of calcium [a] (mg)	Mean ratio: $^{90}Sr/Ca$ (pCi/g)	Estimated daily intake of ^{90}Sr (pCi)
Dairy produce:			
Milk and cream	530	28.0	14.84
Cheese	104	24.7	2.57
Vegetables and fruit:			
Root vegetables	25	48.4	1.21
Leaf and other vegetables	36	30.6	1.10
Fruit, etc	17	30.6	0.52
Flour and cereals	[b] 248	17.4	4.32
Other animal produce:			
Eggs	21	27.6	0.58
Meat	22	56.0	1.23
Other sources:			
Drinking water	60	—	1.07
Tea	—	—	1.10
Miscellaneous	39	—	—
Total mixed diet	1,102	25.9	28.54

[a] Values computed by the Ministry of Agriculture, Fisheries and Food from surveys of domestic food consumption. The values differ slightly from those used to calculate the daily intake in previous years.
[b] This includes about 206 mg mineral calcium added to flour as *creta praeparata*.

The small contribution of meat to the total intake of strontium–90 has been estimated from the results of the countrywide survey of milk on the basis that the ratio of strontium–90 to calcium in meat is about twice that in milk from the same animals; this assumption over-estimates the contribution of meat because about one-third of the total meat supplies in the United Kingdom are imported from the Southern Hemisphere. While these calculated values are adequate to assess the small contributions of meat to the total intake of strontium–90 in any year, they are not suitable for comparison of changes from year to year or of the situation in different countries. The values for drinking water are provided by measurements on water supplies in different parts of the country (*3*). The contribution from tea has been calculated from the measured strontium–90 content of dry tea on the assumption that the average quantity used per head of population is 11 grams per day and that 10 percent of the strontium–90 present in the dry tea is transferred to the tea infusion.

Table 2 shows that there was a fourfold increase in the contamination of the average diet between 1961 and 1964 and that the ratio of strontium–90 to calcium in 1964 (25.9 pCi/g) was almost three times the value for 1959. The total deposit of strontium–90 in fallout during 1964 was appreciably lower than that during 1963; the fact that there was not a comparable reduction in the contamination of diet reflects the delay in the transfer of radioactivity into foodstuffs due to agricultural factors and also,

Table 2. Comparison of levels of strontium-90 in the United Kingdom diet, 1958–1964

Food item	1958	1959	1960	1961	1962	1963	1964
	Mean ratio: $^{90}Sr/Ca$, pCi/g						
Total diet (including drinking water and tea) [a]	5.9	9.0	6.4	6.2	9.9	22.8	25.9
Milk and cream	7.0	9.8	6.4	5.9	11.7	25.6	28.0
Cheese	7.7	7.5	5.3	4.8	8.7	19.7	24.7
Root vegetables	14.2	23.2	19.6	24.3	25.1	53.1	48.4
Leaf vegetables and fruit	8.7	14.3	8.5	10.3	17.6	35.4	30.6
Flour and cereals	15.9	28.0	22.7	21.8	18.4	71.9	[b] 17.4
Eggs	------	9.0	6.3	------	6.2	12.0	27.6
	Intake of strontium-90, pCi/day						
Total diet	6.4	9.8	6.9	6.7	10.7	24.7	28.5
	Percentage of total [c]						
Milk and cream	54.3	49.7	45.7	43.7	54.2	51.4	52.0
Cheese	11.4	7.3	7.2	6.9	7.7	7.6	9.0
Root vegetables	5.5	5.9	7.1	9.1	5.9	5.4	4.2
Leaf vegetables and fruit	8.5	9.0	7.5	9.5	10.2	8.9	5.7
Flour and cereals	11.7	13.5	15.4	15.2	8.0	13.7	15.1
Other foodstuffs	5.0	5.6	5.3	5.2	5.3	4.9	6.3
Drinking water	3.6	4.4	5.2	3.7	3.8	3.4	3.7
Tea	------	4.6	6.5	6.7	4.9	4.7	3.9

[a] Account has been taken of mineral calcium (*creta praeparata*) added to flour.
[b] In contrast to previous years, the value for 1964 is based on the analysis of flour to which mineral calcium as *creta praeparata* had been added. The value comparable with those for previous years, when only the natural calcium was present in the samples analyzed, would be about 100 pCi/g.
[c] Tea was not sampled in 1958, so the percentages for this year are not strictly comparable to the others.

in some instances, to the delay between production and marketing of foods. This was evident in 1962 when the level of strontium–90 in cereal products, in contrast to other foodstuffs, was less than in 1961 because the grain from which they were manufactured was harvested before the rate of fallout increased late in 1961.

The relative contributions of different types of food to the total intake remained fairly constant. From 1962 to 1964, when the rate of fallout was high, dairy produce accounted for about 60 percent of the total, which is a rather higher proportion than in 1961 when the rate of fallout was low for most of the year. As the ratio of strontium–90 to calcium in dairy produce has not differed markedly from that in the mixed diet, variations in the quantity of milk or cheese consumed would have little effect on the ratio of strontium–90 to calcium in the total diet. Since, however, the ratio in milk varied by a factor of about 2.5 between zones of the countrywide survey (*4*), it can be caluculated that, depending on the source of milk, the ratio of strontium–90 to calcium in a mixed diet of otherwise average composition would have varied by a factor of about 1.6 between major areas of the country.

The ratio of strontium–90 to calcium in root vegetables is considerably higher than that in the total diet and the same was true to a lesser extent for leaf vegetables and fruit. The small contribution of both these categories of food to the total intake of strontium–90 (each less than 10 percent) causes the contamination of the total diet to be affected little by variations either in the consumption of these foodstuffs or in their origin.

In considering the effect of changes in the quantity of cereal components in diet, the effect of mineral calcium (*creta praeparata*) which is added to all white flour in the United Kingdom must be taken into account. The estimated daily intake from this source is equivalent to about 200 to 250 mg calcium per day and, as can be seen from table 1, the overall ratio of stronium–90 to calcium in cereal foods containing *creta praeparata* is appreciably lower than that in the total diet. Consequently, although an increase in the consumption of cereal products would add to the total intake of strontium–90, it would cause a decrease in the overall ratio in diet. An exception to this situation would occur if an individual ate only wholemeal bread to which no *creta praeparata* had been added (a product which represents only a small fraction of the country's total supplies). The ratio of strontium–90 to calcium in an otherwise normal diet would then be increased by about one-half.

Cesium–137 in diet

Radiation doses to man from cesium–137 are assessed most satisfactorily from whole-body measurements of radioactivity made on living subjects. Measurements of cesium–137 in diet, however, provide useful supplementary information on the effects of differences in dietary habits and on changes in levels which will subsequently be reflected in whole-body measurements on man.

Cesium–137 has been measured in bulked samples of milk, potatoes, leafy brassicas, and flour collected for the investigation of strontium–90. Cesium–137 was also measured in meat; in 1961 and 1962 only home-produced beef and mutton were sampled but, because meat is a major source of cesium–137 in diet, the scale of sampling was increased in 1963 and 1964 to obtain more widely representative samples from both United Kingdom and overseas sources.

Estimates of the approximate content of cesium–137 in the mixed diet from 1961 to 1964 have been made on the basis of the concentrations of cesium–137 in these foodstuffs and the average daily intake of each food (table 3). The concentrations of cesium–137 in potatoes and leafy brassicas have been taken as representative of those in all root vegetables and leaf vegetables, respectively. The contribution from drinking water (0.3 picocuries per day in 1963 and 1964) is negligible compared with that from components of diet.

Table 3 shows that between 1961 and 1963 there was a marked increase in the contamination of diet with cesium–137, the estimated daily intake from the five types of food assayed rising from about 30 to 170 pCi/day. The concentrations of cesium–137 in milk and flour were higher in 1964 than 1963 but the effect of these increases was offset by reduced estimates for meat and vegetables so that the total intakes for the 2 years were comparable.

Table 3. Estimated mean content of cesium-137 in the mixed diet in the United Kingdom, 1961–1964

Diet items	Mean daily intake (liter or kg)	Cesium-137							
		Concentration, pCi/liter or kg				Estimated daily intake, pCi			
		1961	1962	1963	1964	1961	1962	1963	1964
Milk	0.43	21	62	135	153	9	26	57	66
Meat	0.12	98	330	580	490	11	40	70	59
Flour (in all forms)	0.19	46	30	92	130	9	6	17	25
Root vegetables	0.24	5	32	73	30	1.4	8	19	7
Leaf vegetables	0.11	4	19	40	30	0.4	2	4	3
Total	—	—	—	—	—	31	82	167	160

The total intake of cesium–137 by individuals is likely to vary from the average much more widely than the ratio of strontium–90 to calcium because it is directly related to the quantity of each food consumed and because changes in the origin of foodstuffs, particularly meat, would have a much more pronounced effect.

Strontium–89 and barium–140

Measurements of the relatively short-lived nuclides, strontium–89 and barium–140, were continued during 1962 and 1963. The results confirmed that these nuclides were only minor sources of exposure to radiation.

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Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1,2*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the International Commission on Radiological Protection (*4,5*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature.

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NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	April–June 1965	March 1966
United Kingdom milk	January 1961–April 1962	October 1962

1. Pasteurized Milk Network
February 1966

Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designated to provide nationwide surveillance of radionuclide concentrations in milk through sampling of major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State. In addition, milk is sampled in the Canal Zone and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 issue of *Radiological Health Data* (*1*).

The results for February 1966 and the fourth

Figure 1. Pasteurized Milk Network sampling locations

Table 1. Average concentrations of stable elements and radionuclides in pasteurized milk for the fourth quarter 1965 and February 1966 [a]

Sampling location		Calcium, g/liter		Strontium-89, pCi/liter		Strontium-90, pCi/liter		Cesium-137, pCi/liter	
		Fourth quarter 1965	February 1966	Fourth quarter 1965	February 1966	Fourth quarter 1965	February 1966	Fourth quarter 1965	February 1966
Ala:	Montgomery	1.18	1.17	<5	<5	14	11	30	30
Alaska:	Palmer	1.30	1.26	<5	<5	15	15	55	40
Ariz:	Phoenix	1.25	1.23	<5	<5	4	4	15	15
Ark:	Little Rock	1.20	1.16	<5	<5	27	23	30	40
Calif:	Sacramento	1.27	1.27	<5	<5	4	6	15	10
	San Francisco	1.29	1.22	<5	<5	4	8	15	20
C.Z:	Cristobal	1.13	1.11	<5	<5	5	3	35	25
Colo:	Denver	1.28	1.28	<5	<5	12	11	25	20
Conn:	Hartford	1.12	1.15	<5	<5	12	10	40	35
Del:	Wilmington	1.15	1.18	<5	<5	14	13	35	40
D.C:	Washington	1.16	1.14	<5	<5	13	12	25	30
Fla:	Tampa	1.18	1.18	<5	<5	14	11	135	110
Ga:	Atlanta	1.17	1.12	<5	<5	19	18	45	45
Hawaii:	Honolulu	1.16	1.16	<5	<5	6	4	40	35
Idaho:	Idaho Falls	1.28	1.24	<5	<5	13	13	45	45
Ill:	Chicago	1.14	1.14	<5	<5	11	11	35	35
Ind:	Indianapolis	1.17	1.19	<5	<5	12	13	25	30
Iowa:	Des Moines	1.26	1.26	<5	<5	14	15	20	25
Kans:	Wichita	1.27	1.26	<5	<5	13	13	20	15
Ky:	Louisville	1.16	1.17	<5	<5	17	15	20	25
La:	New Orleans	1.22	1.19	<5	<5	30	28	40	45
Maine:	Portland	1.14	1.12	<5	<5	17	15	65	65
Md:	Baltimore	1.17	1.14	<5	<5	16	13	25	30
Mass:	Boston	1.15	1.16	<5	<5	16	14	60	60
Mich:	Detroit	1.12	1.13	<5	<5	11	11	30	35
	Grand Rapids	1.16	1.17	<5	<5	14	15	45	40
Minn:	Minneapolis	1.26	1.20	<5	5	22	19	40	40
Miss:	Jackson	1.24	1.24	<5	<5	25	21	25	30
Mo:	Kansas City	1.22	1.24	<5	<5	16	15	20	25
	St. Louis	1.27	1.22	<5	<5	18	16	20	30
Mont:	Helena	1.31	1.26	<5	<5	15	14	45	50
Nebr:	Omaha	1.22	1.25	<5	<5	16	16	25	20
Nev:	Las Vegas	1.27	1.24	<5	<5	5	10	25	20
N.H:	Manchester	1.14	1.17	<5	<5	18	20	70	75
N.J:	Trenton	1.14	1.18	<5	<5	11	14	30	40
N. Mex:	Albuquerque	1.23	1.22	<5	<5	6	4	20	10
N.Y:	Buffalo	1.10	1.12	<5	<5	11	10	40	40
	New York	1.11	1.12	<5	<5	14	13	40	45
	Syracuse	1.10	1.13	<5	<5	12	9	35	35
N.C:	Charlotte	1.20	1.18	<5	<5	25	20	30	30
N. Dak:	Minot	1.27	1.23	<5	<5	30	30	40	45
Ohio:	Cincinnati	1.15	1.16	<5	<5	13	12	20	25
	Cleveland	1.14	1.17	<5	<5	13	13	25	35
Okla:	Oklahoma City	1.17	1.16	<5	<5	14	12	20	25
Ore:	Portland	1.27	1.24	<5	<5	12	11	40	30
Pa:	Philadelphia	1.12	1.16	<5	<5	12	12	30	35
	Pittsburgh	1.13	1.17	<5	<5	17	18	40	45
P.R:	San Juan	1.11	1.09	<5	<5	9	8	30	30
R.I:	Providence	1.14	1.15	<5	<5	15	10	45	45
S.C:	Charleston	1.19	1.19	<5	<5	25	23	55	50
S. Dak:	Rapid City	1.23	1.12	<5	<5	21	18	45	40
Tenn:	Chattanooga	1.25	1.19	<5	<5	22	22	30	30
	Memphis	1.18	1.18	<5	<5	18	16	20	20
Tex:	Austin	1.17	1.15	<5	<5	6	6	10	15
	Dallas	1.17	1.17	<5	<5	12	13	20	20
Utah:	Salt Lake City	1.38	1.29	<5	<5	12	14	40	40
Vt:	Burlington	1.12	1.13	<5	<5	14	15	50	50
Va:	Norfolk	1.18	1.18	<5	<5	16	15	25	30
Wash:	Seattle	1.30	1.24	<5	<5	16	16	45	40
	Spokane	1.31	1.26	<5	<5	16	16	45	40
W. Va:	Charleston	1.16	1.14	<5	<5	16	14	20	25
Wis:	Milwaukee	1.20	1.20	<5	<5	12	11	40	45
Wyo:	Laramie	1.29	1.23	<5	<5	16	17	45	35
Network average		1.20	1.19	<5	<5	14.6	13.8	35	35

[a] All iodine-131 and barium-140 values were below detectable levels.

quarter of 1965 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value; however, for iodine–131 and barium–140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, February and September–December 1965, and January–February 1966.

Strontium-90 (pCi/liter)	Number of stations						
	1965					1966	
	Feb	Sept	Oct	Nov	Dec	Jan	Feb
Under 10	3	11	8	9	9	10	9
10–19	31	44	46	43	43	46	46
20–29	22	7	7	9	11	6	7
30–39	5	1	2	2	0	1	1
40–49	2	0	0	0	0	0	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, February and September–December 1965, and January–February 1966.

Cesium-137 (pCi/liter)	Number of stations						
	1965					1966	
	Feb	Sept	Oct	Nov	Dec	Jan	Feb
Under 50	8	50	54	57	51	57	56
50–99	38	12	8	5	11	5	6
100–149	15	0	0	1	1	1	1
150–199	2	1	1	0	0	0	0

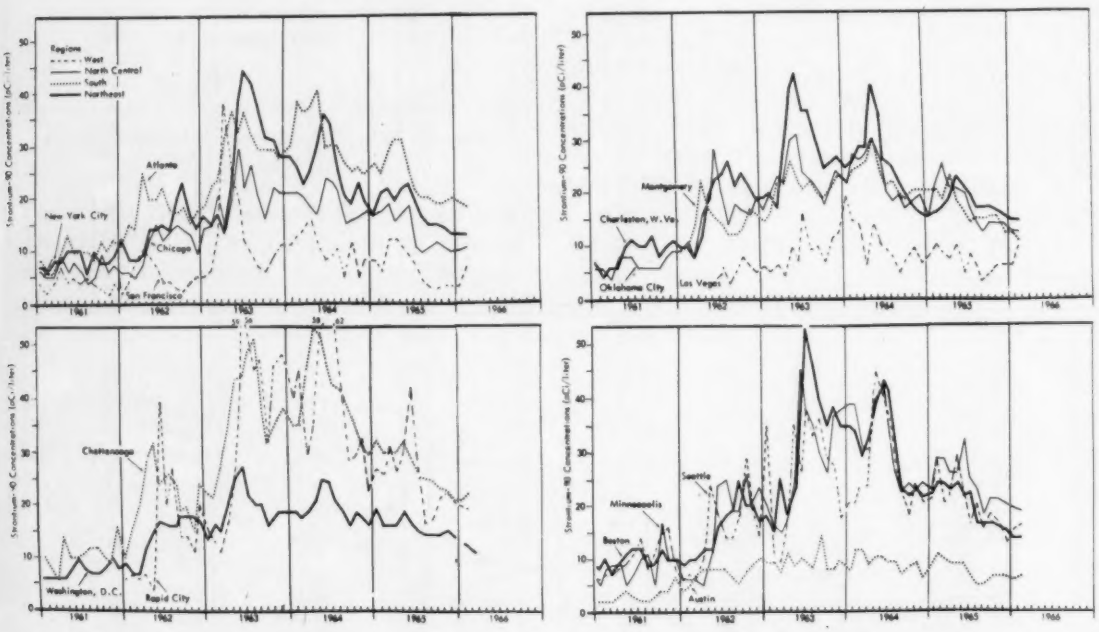

Figure 2. Strontium–90 concentrations in pasteurized milk, 1961–February 1966

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for February 1965 and for September 1965 through February 1966. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2. During this period the monthly average iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter.

2. Canadian Milk Network February 1966[1]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (*2*).

The February 1966 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. During this period strontium–89 and iodine–131 concentrations were below minimum detectable levels.

[1] Prepared from February 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 4. Stable elements and radionuclides in Canadian whole milk, February 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.08	1.5	23.3	66
Edmonton	1.12	1.5	21.9	62
Ft. William	1.10	1.6	30.7	71
Fredericton	1.09	1.5	29.8	76
Halifax	1.00	1.5	23.1	64
Montreal	1.10	1.6	16.7	47
Ottawa	1.12	1.6	14.3	36
Quebec	1.09	1.6	28.1	89
Regina	1.10	1.5	18.3	41
St. John's, Nfld.	1.11	1.5	28.1	89
Saskatoon	1.11	1.7	22.9	47
Sault Ste. Marie	1.10	1.6	26.5	80
Toronto	1.14	1.6	10.6	33
Vancouver	1.16	1.6	21.1	81
Windsor	1.08	1.4	9.5	32
Winnipeg	1.00	1.5	18.2	51
Average	1.09	1.6	21.4	60

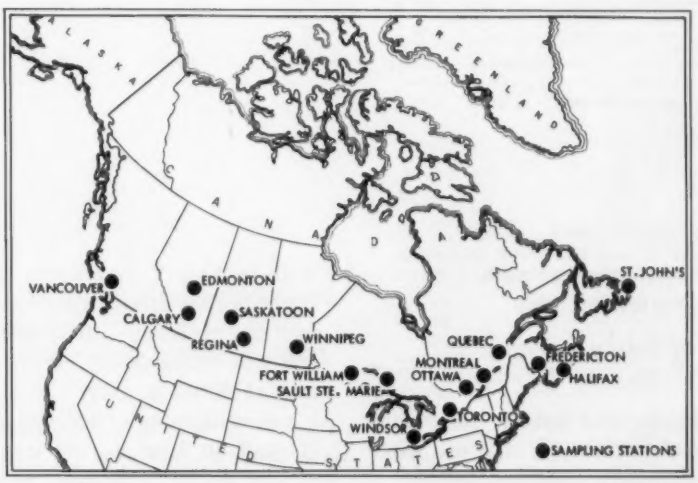

Figure 3. Canadian Milk Sampling Network

3. Pan American Milk Sampling Program February 1966

Pan American Health Organization and Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (*3*).

Table 5 presents stable calcium and potassium, strontium–90, strontium–89, and cesium–137 monthly average concentrations. The monthly average iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter.

Figure 4. Pan American Milk Network

Table 5. PAHO stable elements and radionuclide concentrations in milk, February 1966

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone:					
Cristobal	1.11	1.5	<5	3	25
Jamaica:					
Kingston	NS	NS	NS	NS	NS
Mandeville	1.08	1.22	<5	7	95
Montego Bay	NS	NS	NS	NS	NS
Puerto Rico:					
San Juan	1.09	1.5	<5	8	30
Venezuela:					
Caracas	1.14	1.31	<5	4	10

NS, no sample collected.

4. Radiostrontium in milk July–September 1965[2]

Health and Safety Laboratory U.S. Atomic Energy Commission

In 1954, the Health and Safety Laboratory began monitoring strontium–90 in liquid whole milk in New York City to estimate the dietary contribution from ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, New York (1954), and at Mandan, North Dakota (1955). Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu samples are monthly composites of

[2] Data summarized from "Fallout Program Quarterly Summary Report, HASL 171," available from Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151. Price $4.00.

quart samples of pasteurized milk collected weekly. Samples from two dairies are analyzed and the results are averaged for reporting purposes. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used in cattle feeds. Because of its protein and fat content, this buttermilk powder is used primarily as a milk replacer or feed supplement for calves. The Perry sample is powdered whole milk used for human consumption. The source of the Honolulu milk is a herd on the island of Oahu where the cows are on pasture throughout the year. Sampling at Mandan and Honolulu was discontinued at the end of June 1965.

Table 6. Strontium-90 and calcium in liquid milk July–December 1965

Sampling station and periods	Calcium concentration (g/liter)	Strontium-90 concentration (pCi/liter)	Strontium-90/ calcium ratio (pCi/g)
New York, New York			
1965			
July	1.01	18.2	18.0
August	10.77	16.6	21.6
September	1.04	17.1	16.5
October	1.00	17.6	17.6
November	10.77	12.3	16.0
December	0.98	16.8	17.1
Honolulu, Hawaii			
1965			
July	NS	NS	NS
August	NS	NS	NS
September	NS	NS	NS
October	NS	NS	NS
November	NS	NS	NS
December	NS	NS	NS

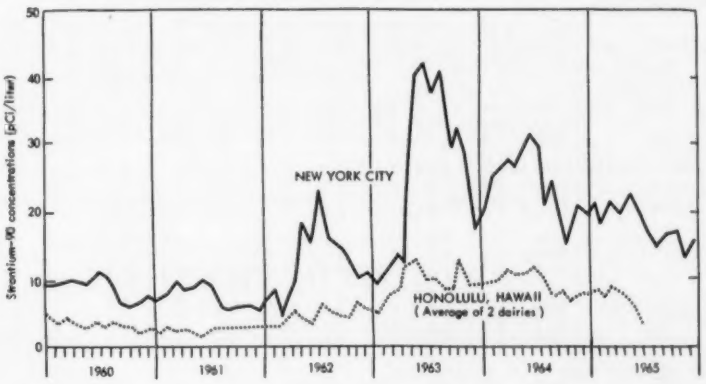

Figure 5. Strontium–90 in liquid milk samples

Results and discussion

The calcium and strontium–90 concentrations in liquid whole milk are presented in table 6, and the strontium–90 data are plotted in figure 5.

Strontium–90 concentrations are shown in powdered milk (table 7) and powdered buttermilk (table 8) and plotted in figure 6. The general decreasing trend in strontium–90 levels

Table 7. Strontium-90 and calcium in powdered milk April–June 1965, and annual average strontium-90 concentrations in powdered milk, 1959–1964

Sampling station and month	Calcium concentration (g/kg)	Strontium-90 concentration (pCi/kg)	Strontium-90/ calcium ratio (pCi/g)
Perry, New York			
1965			
July	8.78	132	15.1
August	8.88	115	12.9
September	8.50	99	11.6
October	8.63	94	10.9
November	8.61	101	11.7
December	8.82	104	11.7

Table 8. Strontium-90 to calcium ratio in milk, 1954–1965

Station and type of milk	Year	Strontium-90 to calcium ratio, pCi/g												
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Average
New York, New York: liquid milk	1954	NS	NS	NS	NS	NS	0.5	0.9	0.6	2.3	1.8	1.7	1.8	—
	1955	1.5	0.9	1.1	0.9	2.4	3.7	5.2	2.4	4.0	3.9	3.6	3.8	2.8
	1956	4.2	3.7	3.7	3.5	4.2	NS	NS	NS	NS	NS	NS	NS	—
	1957	3.2	4.1	3.8	3.7	4.0	5.5	6.6	4.6	4.9	5.7	4.7	2.9	4.5
	1958	3.6	4.0	3.2	4.1	3.9	10.2	11.3	10.9	10.6	9.9	11.7	8.2	7.6
	1959	8.2	8.4	8.0	7.7	13.4	24.2	14.1	10.7	9.8	8.3	10.2	9.2	11.0
	1960	8.1	8.9	9.1	8.7	8.8	10.1	9.8	8.6	6.1	6.1	5.9	6.3	8.0
	1961	6.7	7.3	8.1	6.5	8.1	8.4	7.0	5.4	5.2	6.0	6.1	5.7	6.7
	1962	5.7	6.1	4.0	9.1	14.8	14.5	23.2	17.4	15.3	13.6	10.3	10.9	12.1
	1963	8.3	11.2	13.4	12.1	40.6	42.4	35.8	40.5	27.1	29.6	25.9	20.7	25.6
	1964	21.1	23.9	27.2	26.1	30.8	30.9	22.0	24.9	17.1	14.8	19.7	19.3	23.2
	1965	20.8	18.0	21.1	19.0	22.9	18.0	18.0	21.6	16.5	17.6	16.0	17.1	19.1
Perry, New York: powdered whole milk	1954	NS	NS	NS	0.5	1.2	1.3	1.5	1.2	1.5	1.4	1.1	0.6	—
	1955	2.5	0.8	0.8	0.3	1.9	2.5	1.9	2.0	1.5	2.8	2.5	3.3	1.9
	1956	2.3	2.0	2.0	2.9	2.8	3.0	2.7	3.1	4.9	5.4	5.6	3.2	3.3
	1957	3.8	4.0	3.0	3.1	3.9	4.6	4.7	4.2	4.3	3.6	4.4	2.6	3.8
	1958	3.4	3.6	3.0	3.0	5.0	5.4	8.6	7.2	6.6	7.8	10.0	6.9	5.9
	1959	8.1	7.6	6.6	7.2	8.9	8.9	10.0	7.8	6.1	10.5	7.0	7.7	8.0
	1960	8.7	8.6	7.3	7.7	7.3	7.1	7.7	5.5	5.0	5.1	4.2	4.8	6.6
	1961	6.5	7.0	6.5	7.2	6.6	5.9	6.3	5.8	6.5	5.8	5.1	5.9	6.2
	1962	5.2	5.0	5.6	5.6	8.8	13.0	21.7	15.6	14.2	13.6	12.8	12.3	11.1
	1963	12.5	11.4	11.9	11.8	18.3	30.5	30.1	27.1	30.6	30.1	22.2	22.1	21.6
	1964	20.1	21.7	20.9	21.0	19.3	24.2	28.0	22.1	18.8	16.0	14.7	18.0	20.4
	1965	17.7	14.2	19.0	18.3	16.9	13.3	15.1	12.9	11.6	10.9	11.7	11.7	14.4
Honolulu, Hawaii: liquid milk Dairy A	1959	NS	NS	NS	NS	NS	NS	NS	6.1	3.9	6.8	3.7	3.3	—
	1960	3.4	3.5	3.6	4.3	2.2	2.7	2.4	2.5	2.3	2.7	1.8	3.2	2.9
	1961	1.8	2.4	1.9	2.0	2.1	1.6	1.5	2.4	1.5	2.2	3.2	3.1	2.1
	1962	2.4	2.1	2.6	3.9	4.5	2.4	4.2	3.1	5.5	4.8	2.4	3.7	3.5
	1963	4.8	4.3	6.0	6.4	7.3	10.1	8.9	6.5	7.4	8.5	6.1	6.8	6.9
	1964	6.9	7.2	8.3	8.4	8.6	11.2	9.8	6.3	7.3	7.2	7.1	7.2	8.0
	1965	7.0	6.8	7.7	7.3	6.7	4.7	NS	NS	NS	NS	NS	NS	—
Dairy B	1959	NS	NS	NS	NS	NS	NS	NS	5.8	4.8	6.0	4.5	5.4	—
	1960	4.2	3.5	5.2	3.3	3.6	3.9	3.6	3.8	3.4	3.2	2.7	2.2	3.6
	1961	2.7	3.5	3.1	2.8	1.9	2.6	2.2	2.5	3.9	3.2	2.1	2.2	2.7
	1962	2.8	3.6	3.6	5.8	3.8	3.9	7.7	6.4	3.0	3.9	7.8	7.5	5.0
	1963	4.8	7.0	9.3	9.5	11.9	8.8	9.0	8.6	7.3	16.4	8.6	8.0	9.1
	1964	8.7	9.2	13.1	11.1	11.9	11.1	9.6	7.0	7.5	6.3	8.5	8.0	9.3
	1965	8.8	8.3	10.2	7.8	6.8	4.4	NS	NS	NS	NS	NS	NS	—
Mandan, North Dakota: powdered buttermilk	1955	NS	NS	NS	NS	7.3	9.2	6.3	5.8	4.7	6.9	7.4	10.0	—
	1956	3.5	8.1	11.0	9.6	17.0	8.7	6.6	8.6	10.7	8.9	5.1	7.4	8.8
	1957	4.4	8.2	7.4	6.8	9.8	10.9	17.3	32.7	24.2	25.6	29.6	20.1	16.4
	1958	15.2	16.5	15.6	21.6	21.3	26.3	26.7	20.2	19.4	20.8	23.1	19.2	20.5
	1959	20.8	18.4	23.9	27.8	47.5	37.9	22.2	24.0	16.6	20.9	23.5	25.0	25.7
	1960	22.6	21.8	22.5	24.4	21.4	11.5	9.6	10.0	9.1	8.1	9.1	10.6	15.0
	1961	10.4	11.6	10.9	12.2	12.0	9.6	7.3	7.4	5.1	8.0	9.4	8.5	9.4
	1962	7.7	7.8	16.0	20.6	28.7	28.8	33.1	26.8	35.9	31.5	28.8	31.1	24.7
	1963	26.6	31.3	30.0	42.2	105	56.5	53.2	59.2	61.0	83.7	75.6	68.6	57.7
	1964	68.3	81.8	73.2	81.2	100	67.5	44.8	34.8	41.0	50.0	53.0	56.8	62.7
	1965	54.6	50.0	61.8	60.7	66.3	32.4	NS	NS	NS	NS	NS	NS	—

NS, no sample collected

can be expected. The current powdered milk results are shown in figure 6 in relation to results since January 1960. It has been assumed that 0.1 kilogram of powdered milk is used to prepare a liter of liquid milk.

A summary of strontium–90 to calcium ratio data in milk for Perry and New York City, New York; Honolulu, Hawaii; and Mandan, North Dakota, since the inception of the sampling programs is given in table 8.

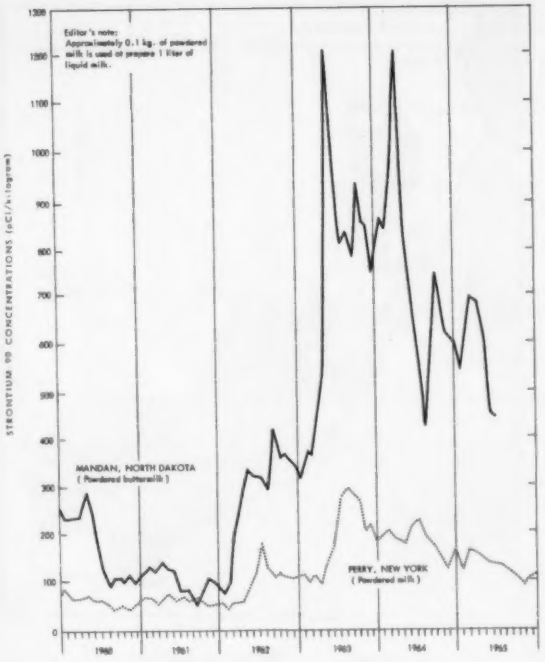

Figure 6. Strontium–90 in powdered milk samples

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1963	January 1964
July–September 1963	April 1964
Ocober–December 1963	July 1964
January–December 1964	June 1965
January–March 1965	September 1965
April–June 1965	March 1966

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH, and DIVISION OF ENVIRONMENTAL ENGINEERING AND FOOD PROTECTION. Milk surveillance, Pasteurized Milk Network, August 1965. Rad Health Data 6:677–681 (December 1965).

(*2*) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION, OTTAWA, CANADA. Canadian Milk Network, August 1965. Rad Health Data 6:685–686 (December 1965).

(*3*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Rad Health Data 6:687 (December 1965).

STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have progressed to a state of comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein, while not inclusive, are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

State milk network	Period reported	Last presented
Colorado	October–December 1964	April 1965
Connecticut	April–September 1965	February 1966
Florida	July–December 1965	April 1966
Indiana	July–September 1965	February 1966
Michigan	July–September 1965	February 1966
Minnesota	January–June 1965	January 1966
New York	April–June 1965	January 1966
Oklahoma	August–December 1965	April 1966
Pennsylvania	July–September 1965	February 1966
Texas	April–December 1965	April 1966

1. California Milk Network October–December 1965 and Annual Summaries 1964 and 1965

Division of Environmental Sanitation
State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of California's Department of Health program of radiation control. This milk monitoring function has been conducted at eight milksheds since January 1960 by the Department's Bureau of Radiological Health. With the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly, biweekly, or monthly sampling of pasteurized milk has been conducted at 10 major milksheds (figure 1). The original sampling locations were chosen by the State Department of Agriculture so as to be representative of milk consumed by a high percentage of the State's population. A description of the various California milksheds was presented earlier by Heslep and Cornish (*1*).

Strontium–89 and strontium–90 concentrations are determined radiochemically.

Potassium–40, iodine–131, cesium–137, and barium–140 in whole fluid milk are determined by gamma-scintillation spectrometry. A detailed description of the analytical procedures was presented earlier (*2*).

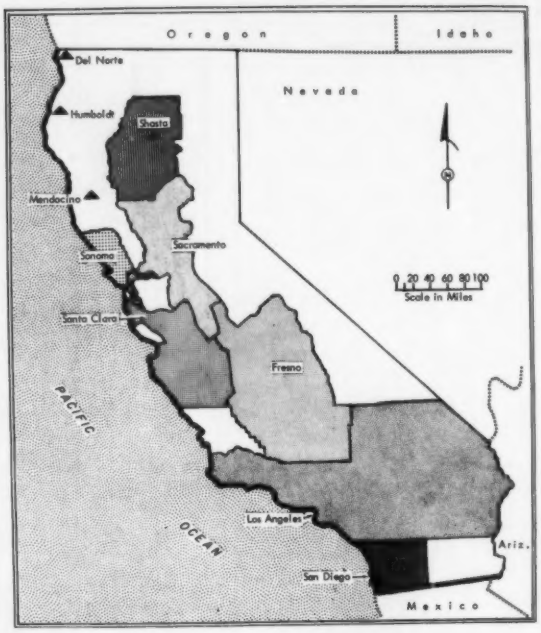

Figure 1. California milksheds

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 1 for the period October to December 1965.

Table 1. Stable elements and radionuclides in California milk October–December 1965

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)											
October	1.40	1.26	1.35	1.18	1.26	1.25	1.20	1.11	1.15	1.29	1.25
November	1.28	1.18	1.21	1.06	1.25	1.22	1.05	1.08	1.11	1.12	1.16
December	1.32	1.23	1.24	1.07	1.29	1.21	1.10	1.13	1.18	1.18	1.20
Potassium-40 (pCi/liter)											
October	1,130	1,180	1,140	1,360	1,280	1,210	1,190	1,170	1,190	1,170	1,200
November	1,170	1,190	1,060	1,250	1,240	1,260	1,220	1,170	1,260	1,190	1,200
December	1,110	1,180	1,160	1,250	1,240	1,290	1,210	1,130	1,240	1,240	1,200
Strontium-89 (pCi/liter)											
October	*0.4	ND	*0.7	NA	*0.1	ND	*1.1	ND	0.3	NA	0.3
November	ND	0.8	0.7	ND	0.4	ND	ND	0.2	ND	0.5	0.3
December	2.7	0.6	0.4	*0.6	ND	ND	ND	ND	ND	1.5	0.6
Strontium-90 (pCi/liter)											
October	17	2.8	5	3.0	3.8	4.0	1.5	2.3	4.4	5.0	4.9
November	26	2.6	7	4.5	5.4	4.5	2.1	3.0	5.2	3.7	6.4
December	24	2.5	10	3.1	4.4	4.0	3.7	3.0	5.4	3.0	6.5
Cesium-137 (pCi/liter)											
October	25	*9	13	26	12	14	12	17	22	28	18
November	43	15	17	12	8	18	11	18	17	24	18
December	72	19	35	18	18	21	14	12	29	31	27

*When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.
NA, no analysis performed
ND, below detectable levels.

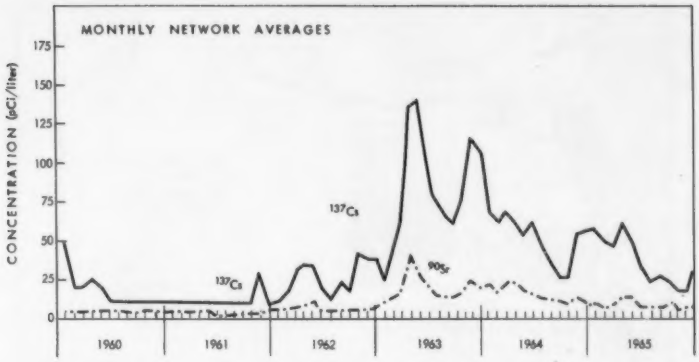

Figure 2. Radionuclide concentrations in California milk, 1960–1965

Table 2. Monthly average radionuclide concentrations in California milk 1964–1965

Month and year	Calcium (g/liter)	Potassium (pCi/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
1964					
January	1.20	1,260	8	20	67
February	1.22	1,220	8	16	62
March	1.21	1,230	4	21	67
April	1.20	1,260	1.9	22	59
May	1.22	1,240	0.7	17	52
June	1.17	1,260	1.4	15	60
July	1.18	1,230	2	12	43
August	1.14	1,220	ND	11	33
September	1.19	1,180	1	9	22
October	1.15	1,200	NA	8	22
November	1.23	1,140	6.8	11	51
December	1.25	1,150	6.0	10	55
1965					
January	1.22	1,210	NA	12	58
February	1.22	1,260	NA	11	50
March	1.20	1,220	NA	12	46
April	1.21	1,190	0.9	14	61
May	1.33	1,230	0.4	14	49
June	1.21	1,200	0.4	9	32
July	1.17	1,200	0.9	8	22
August	1.18	1,210	0.4	6	24
September	1.23	1,000	0.3	5	20
October	1.25	1,202	0.3	4.9	18
November	1.16	1,200	0.3	6.4	18
December	1.20	1,204	0.6	6.5	27

ND, no detectable activity
NA, no analysis performed

Network average strontium–90 and cesium–137 concentrations are presented graphically in figure 2. Superimposed upon normal seasonal variations is a decreasing trend since the peak which occurred in the spring of 1963. A summary of monthly average concentrations in milk is given in table 2 for 1964 and 1965.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1964	September 1964
April–June 1964	December 1964
July–September 1964	March 1965
October–December 1964	June 1965
January–March 1965	September 1965
April–June 1965	December 1965
July–September 1965	March 1966

2. Oregon Milk Network October–December and Annual Summary 1965

Division of Sanitation and Engineering
Oregon State Board of Health

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program, routine milk samples are collected at eight major production areas (figure 3), which supply 90 percent of the milk distributed in Oregon. Currently, pasteurized milk samples are collected monthly by the Oregon Department of Agriculture except in the Portland area where weekly samples are collected by the city of Portland. The milk-sampling frequency is accelerated to a weekly basis in areas where iodine–131 con-

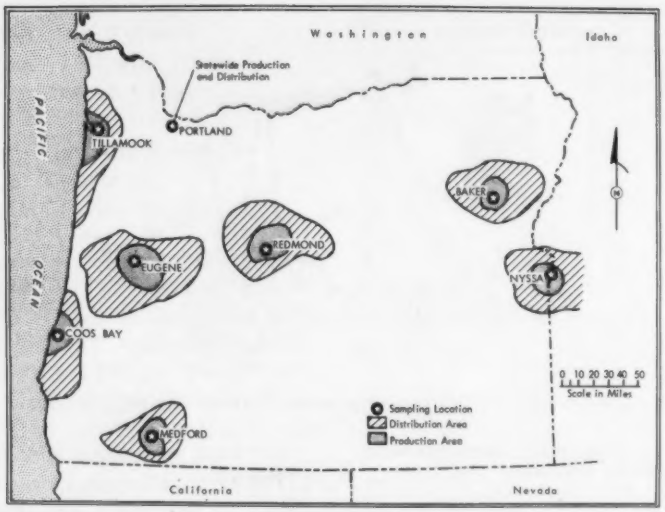

Figure 3. Oregon milk production and distribution areas

centrations exceed 100 pCi/liter, or where cesium–137 concentrations exceed 500 pCi/liter. Strontium–90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

Strontium–90 concentrations are determined using a trichloracetic acid analytical procedure (*3*). Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-scintillation spectrometry (*4*).

Table 3 gives the strontium–90 and cesium–137 concentration in pasteurized milk from October through December 1965. These data are presented graphically in figure 4. Iodine–131 and barium–140 concentrations remained below minimum detectable levels of 15 pCi/liter.

Table 3. Radionuclide concentrations in Oregon milk October–December 1965

Location	Sampling frequency	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
		Oct	Nov	Dec	Oct	Nov	Dec
Baker	M	NA	10	NA	30	25	25
Coos Bay	M	NA	19	NA	45	60	50
Eugene	M	NA	11	NA	25	30	35
Medford	M	NA	15	NA	75	45	20
Nyssa	M	NA	12	NA	20	25	25
Portland composite	W	12	13	11	38	41	36
Portland local	W	NA	16	NA	45	51	50
Redmond	M	NA	10	NA	40	50	40
Tillamook	M	NA	29	NA	50	90	65
Average	—	12	15	11	41	46	37

M, sampled monthly
NA, no analysis performed
W, sampled weekly

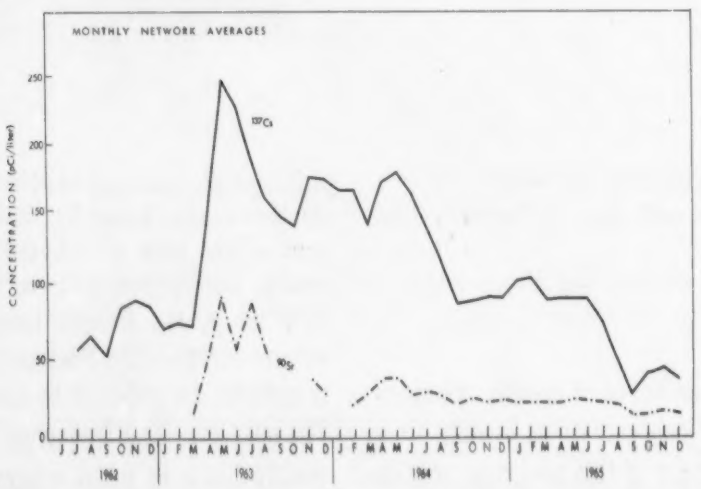
MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
250
200
150
100
50
0
137Cs
90Sr
J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1962
1963
1964
1965

Figure 4. Radionuclide concentrations in Oregon milk network, 1962–1965

A summary of radionuclide concentrations in Oregon pasteurized milk is presented in table 4 for 1965.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1964 and Summary 1962–1964	June 1965
January–March 1965	August 1965
April–June 1965	December 1965
July–September 1965	March 1966

Table 4. Monthly average radionuclide concentrations in Oregon pasteurized milk, 1965

1965	Concentration, pCi/liter	
	Strontium-90	Cesium-137
January	21	101
February	NA	103
March	21	89
April	NA	90
May	24	90
June	NA	90
July	19	66
August	13	55
September	15	40
October	12	41
November	15	46
December	11	37

NA, no analysis

3. Washington Milk Network October–December and Annual Summaries for 1964 and 1965

Air Sanitation and Radiation Control Section
State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 5 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area forms a part of the Spokane milkshed. Details of the sampling procedures were presented earlier (*5*).

Selected samples are analyzed radiochemically for strontium–90. Potassium–40, iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectrometry. Details of the analytical procedures were presented earlier (*5*).

Table 5 presents monthly radionuclide concentrations in Washington raw milk for October through December 1965. During this period, iodine–131 and barium–140 concentrations remained below minimum detectable levels. Monthly average strontium–90 and cesium–137 concentrations are presented graphically in figure 6, so as to display general trends.

Zinc–65 was observed in the Benton-Franklin area on three occasions during this period (table 6). This nuclide has periodically appeared in this area as a result of the irrigation of some pasture land with Columbia River water which has been shown to contain this contaminant.

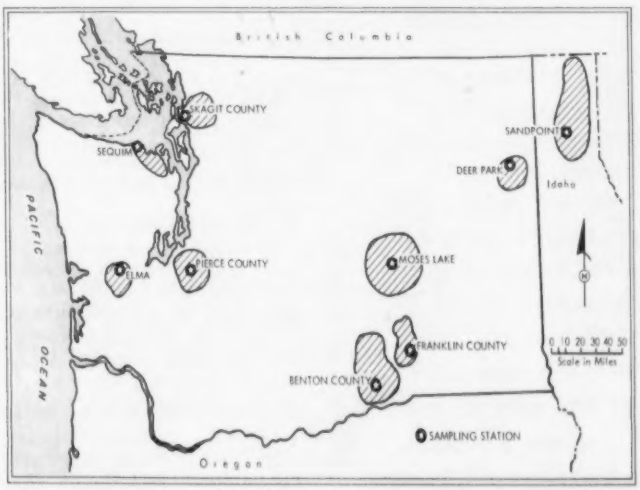

Figure 5. Washington milksheds and sampling locations

Table 5. Radionuclide concentrations in Washington milk October–December 1965

Sampling location	October	November	December
	Potassium-40, pCi/liter		
Benton County	1,250	NS	1,290
Deer Park	1,280	1,210	1,350
Elma	1,250	1,220	1,330
Franklin County	NS	1,110	NS
Moses Lake	1,330	1,260	1,300
Pierce County	1,170	1,260	1,260
Sandpoint	1,300	1,140	1,260
Sequim	1,040	1,130	1,350
Skagit County	1,030	1,250	1,140
Average	1,210	1,200	1,290
	Strontium-90, pCi/liter		
Benton County	6	NS	6
Deer Park	14	15	15
Elma	22	10	10
Franklin County	NS	6	NS
Moses Lake	5	7	8
Pierce County	12	16	8
Sandpoint	27	28	36
Sequim	8	9	8
Skagit County	18	18	16
Average	14	14	13
	Cesium-137, pCi/liter		
Benton County	18	NS	24
Deer Park	40	42	50
Elma	49	45	24
Franklin County	NS	22	NS
Moses Lake	20	18	33
Pierce County	45	54	29
Sandpoint	79	82	94
Sequim	34	31	20
Skagit county	56	29	45
Average	43	40	40

NS, no sample collected.

Table 6. Milk samples in Washington State containing zinc-65

Sampling location	Date (1965)	Zinc-65 (pCi/liter)
Benton County	October 4	38
Franklin County	November 3	98
Benton County	December 10	44

MONTHLY NETWORK AVERAGES
Concentrations (pCi/liter)
137Cs
90Sr
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1962
1963
1964
1965

Figure 6. Radionuclides in Washington milk, December 1962–December 1965

A summary of the radionuclide concentrations in Washington raw milk is presented in table 7 for 1964 and 1965.

Table 7. Network average radionuclide concentrations in Washington raw milk, 1964–1965

Year and month	Concentration, pCi/liter		
	Potassium-40	Strontium-90	Cesium-137
1964			
January	1,220	19	119
February	1,260	26	139
March	1,160	20	146
April	1,160	22	145
May	1,180	29	146
June	1,140	39	205
July	1,210	21	169
August	1,160	18	117
September	1,210	20	131
October	1,200	19	104
November	1,180	21	107
December	1,210	19	111
1965			
January	1,180	18	115
February	1,200	18	109
March	1,220	18	93
April	1,190	17	93
May	1,200	24	90
June	1,170	19	81
July	1,250	15	77
August	1,260	15	75
September	1,210	13	56
October	1,210	14	43
November	1,200	14	40
December	1,290	13	40

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
December 1962–December 1963	May 1964
January–June 1964	February 1965
July–December 1964	May 1965
January–June 1965	November 1965
July–September 1965	March 1966

REFERENCES

(*1*) HESLEP, J. M., and A. C. CORNISH. California Milk Network and milkshed comparisons, April-June 1963. Rad Health Data 4:596–599 (December 1963).

(*2*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California Milk Network, 1960–June 1962. Rad Health Data 4:90–92 (February 1963).

(*3*) MURTHY, G. K., J. E. COAKLEY, and J. E. CAMPBELL. A method for the elimination of ashing in strontium-90 determinations in milk. J. Dairy Sci 43:151–154 (1960).

(*4*) OREGON STATE BOARD OF HEALTH, DIVISION OF SANITATION AND ENGINEERING. Oregon Milk Network, April–June 1965. Rad Health Data 6:683–684 (December 1965).

(*5*) STATE OF WASHINGTON DEPARTMENT OF HEALTH, AIR AND RADIATION CONTROL SECTION. Washington Milk Network, January–June 1965. Rad Health Data 6:619–621 (November 1965).

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. While not based on probability sampling, these networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs previously covered in *Radiological Health Data and Reports* include:

Program	Period reported	Last presented
Institutional Total Diet	July–September 1965	May 1966
Teenage Diet	February–November 1964	July 1965
California Diet	January–April 1965	March 1966

1. Strontium-90 in Tri-City Diets August–October 1965[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium-90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium-90. Fourteen of the diet categories are analyzed on a quarterly basis. Eggs, poultry, fresh fish, shellfish, and meat are purchased quarterly, but analyzed annually. This policy was initiated in 1965 due to the lower concentrations of strontium-90 in these food categories. The contribution of these five diet categories to the total annual intake of strontium-90 over the last 4 years has been approximately 5 percent. Therefore, this figure is used to calculate the contribution of these food categories to the total diet strontium-90 intake. These values are added to the contributions of the other 14 food categories to obtain quarterly estimates of annual strontium-90 intake at the three cities. Consumption figures used are based upon data from the Department of Agriculture (*1*).

Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city, it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this material. Details

[1] Data from Fallout Program Quarterly Summary Report, HASL 171. Available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151.

of the sampling system and a discussion of the results obtained have been summarized (*3*).

Results of the August to October 1965 sampling are presented in table 1. The variation with time of the daily intake of strontium–90 in the three cities is plotted in figure 1. A discussion of cesium–137 intakes from the Tri-City Diet Study is presented elsewhere (*4*).

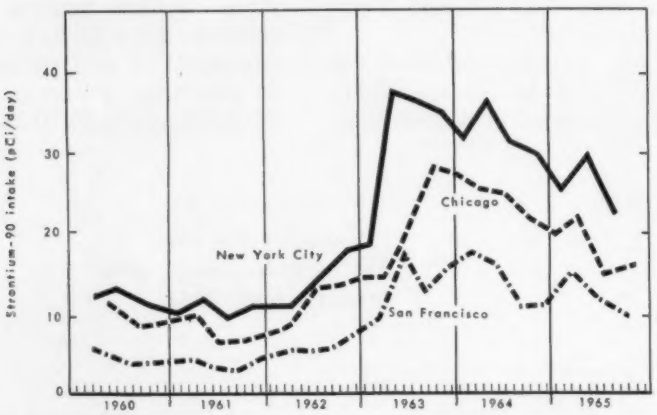

Figure 1. Daily intake of strontium-90 in Tri-City diets 1960–October 1965

Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet August–October 1965

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City, August 1965		Chicago, October 1965		San Francisco, September 1965	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Bakery products	37	37.0	29.5±1.2	1,092	15.6±1.1	577	12.2±1.1	451
Whole grain products	11	10.0	36.9±1.2	406	35.6±1.7	392	30.8±1.2	339
Fresh vegetables	43	15.0	12.9±0.4	555	13.1±0.5	563	2.4±0.3	103
Root vegetables	17	6.1	10.3±0.4	175	18.3±0.5	311	6.5±0.4	111
Milk	221	234.4	16.6±0.5	3,669	12.0±0.5	2,652	4.7±0.2	1,039
Flour	43	8.6	22.2±0.4	955	13.9±0.4	598	6.0±0.2	258
Macaroni	3	0.7	14.6±0.4	44	14.8±0.8	44	12.6±0.4	38
Rice	3	1.1	2.2±0.4	7	6.6±0.5	20	5.3±0.4	16
Dried beans	3	2.9	25.2±0.4	76	19.5±1.5	59	22.7±1.9	68
Fresh fruit	68	12.6	3.4±0.3	231	1.8±0.2	122	4.4±0.3	299
Potatoes	45	5.8	1.0±0.5	45	0.6±0.1	27	13.2±0.8	594
Canned fruit	26	1.3	3.2±0.1	83	4.1±0.2	107	1.7±0.1	44
Fruit juices	19	1.7	6.4±0.3	122	7.0±0.3	133	3.9±0.2	74
Canned vegetables	20	4.2	16.9±0.5	388	15.2±0.7	304	1.2±0.6	24
Meat, fish, poultry, shellfish, and eggs	99	42.0		[a] 410		[a] 311		[a] 182
Annual intake	—	383	—	8,208	—	6,220	—	3,640
pCi strontium-90/g calcium				21.4		16.2		9.5

[a] Estimated as 5 percent of total intake.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue	Period	Issue
Sixteenth Sampling (February 1964–April 1964)	December 1964	Nineteenth Sampling (November 1964–January 1965)	September 1965
Seventeenth Sampling (July–September 1964)	March 1965	Twentieth Sampling (February–April 1965)	December 1965
Eighteenth Sampling (August–October 1964)	June 1965	Twenty first Sampling (May–July 1965)	March 1966

2. Estimated daily intake of radionuclides in Califoria diets, May–August 1965

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*5*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest.

Hospitals were chosen as the source of diet samples under the hypothesis of their being as "reasonably representative" as any other. General hospitals exist in each of the selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected once every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the laboratory, each sample is homogenized, dried, and ashed prior to determination of stable calcium, potassium, strontium, and sodium.

The radiochemical analyses are based upon three basic procedures: chemical separations of strontium–89 and strontium–90; analysis of radium–226; and gamma spectrometry of the entire wet sample.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 2 for May through June 1965, and table 3 for July through August 1965.

Table 2. Estimated daily intake of radionuclides in California diets, May–June 1965 [a]

City	Kg/capita/day [b]	pCi/capita • day						Grams/capita • day			
		^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	^{141}Ce-^{144}Ce	K [c]	Na	Ca	Stable Sr [d]
Bakersfield	2.1	9	0.5	84	6	0	0	2.5	3.3	0.0	0.001
Berkeley	2.7	18	0.3	82	7	5	3	2.8	5.3	0.9	NA
Bishop	1.8	11	0.3	65	7	0	0	2.2	3.7	0.6	0.001
Brawley	2.3	8	0.5	NA	NA	NA	NA	2.8	4.5	0.6	0.003
Crescent City	2.1	7	0.2	106	14	0	0	1.5	2.4	0.6	0.001
Eureka	1.7	16	0.5	77	4	0	4	4.3	3.1	0.8	NA
Fresno	2.5	12	0.9	0	0	0	0	2.5	4.7	1.2	NA
Los Angeles	2.7	11	0.4	78	5	0	1	2.3	3.0	0.1	0.001
Needles	2.2	9	0.4	67	6	0	6	2.0	3.0	0.7	0.001
Quincy	1.7	14	0.5	57	8	0	2	2.3	3.0	0.7	0.001
Redding	2.0	13	0.2	82	5	0	2	2.0	4.0	0.9	0.001
Sacramento	2.8	23	0.9	90	7	0	0	3.3	6.8	1.3	0.004
Salinas	2.4	16	0.8	63	7	0	0	4.0	8.0	1.2	0.008
San Bernardino	2.0	9	0.5	48	4	0	0	2.3	6.2	1.4	0.001
San Diego	2.2	14	0.7	55	0	0	1	3.0	5.0	1.0	0.006
San Luis Obispo	1.3	8	0.3	40	3	0	0	2.2	3.0	0.6	0.001
Santa Barbara	2.1	11	0.3	63	7	3	7	2.7	4.0	0.8	0.001
Santa Rosa	2.3	13	0.2	67	9	0	0	2.6	3.1	1.0	0.001
Susanville	1.6	12	0.3	71	10	0	0	2.0	5.0	0.6	0.001
Ukiah	2.0	17	1.0	88	11	0	0	2.4	2.3	1.5	0.001

[a] Based on analyses of hospital standard diets located in listed cities. Strontium-89 was not detectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
[d] Stable strontium consists of ^{88}Sr—82.7 percent; ^{87}Sr—7.0 percent; ^{86}Sr—9.8 percent; ^{84}Sr—0.5 percent; total—100 percent.
NA, no analysis performed.

of the sampling system and a discussion of the results obtained have been summarized (*3*).

Results of the August to October 1965 sampling are presented in table 1. The variation with time of the daily intake of strontium–90 in the three cities is plotted in figure 1. A discussion of cesium–137 intakes from the Tri-City Diet Study is presented elsewhere (*4*).

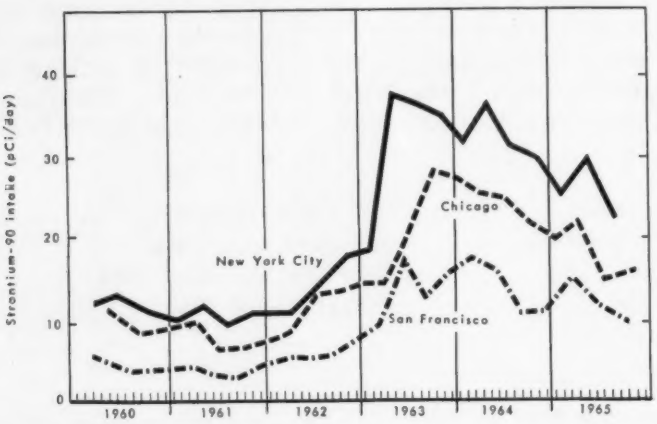

Figure 1. Daily intake of strontium-90 in Tri-City diets 1960–October 1965

Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet August–October 1965

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City, August 1965		Chicago, October 1965		San Francisco, September 1965	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Bakery products	37	37.0	29.5±1.2	1,092	15.6±1.1	577	12.2±1.1	451
Whole grain products	11	10.0	36.9±1.2	406	35.6±1.7	392	30.8±1.2	339
Fresh vegetables	43	15.0	12.9±0.4	555	13.1±0.5	563	2.4±0.3	103
Root vegetables	17	6.1	10.3±0.4	175	18.3±0.5	311	6.5±0.4	111
Milk	221	234.4	16.6±0.5	3,669	12.0±0.5	2,652	4.7±0.2	1,039
Flour	43	8.6	22.2±0.4	955	13.9±0.4	598	6.0±0.2	258
Macaroni	3	0.7	14.6±0.4	44	14.8±0.8	44	12.6±0.4	38
Rice	3	1.1	2.2±0.4	7	6.6±0.5	20	5.3±0.4	16
Dried beans	3	2.9	25.2±0.4	76	19.5±1.5	59	22.7±1.9	68
Fresh fruit	68	12.6	3.4±0.3	231	1.8±0.2	122	4.4±0.3	299
Potatoes	45	5.8	1.0±0.5	45	0.6±0.1	27	13.2±0.8	594
Canned fruit	26	1.3	3.2±0.1	83	4.1±0.2	107	1.7±0.1	44
Fruit juices	19	1.7	6.4±0.3	122	7.0±0.3	133	3.9±0.2	74
Canned vegetables	20	4.2	16.9±0.5	388	15.2±0.7	304	1.2±0.6	24
Meat, fish, poultry, shellfish, and eggs	99	42.0		[a] 410		[a] 311		[a] 182
Annual intake	—	383	—	8,208	—	6,220	—	3,640
pCi strontium-90/g calcium				21.4		16.2		9.5

[a] Estimated as 5 percent of total intake.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue	Period	Issue
Sixteenth Sampling (February 1964–April 1964)	December 1964	Nineteenth Sampling (November 1964–January 1965)	September 1965
Seventeenth Sampling (July–September 1964)	March 1965	Twentieth Sampling (February–April 1965)	December 1965
Eighteenth Sampling (August–October 1964)	June 1965	Twenty first Sampling (May–July 1965)	March 1966

2. Estimated daily intake of radionuclides in Califoria diets, May–August 1965

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*5*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest.

Hospitals were chosen as the source of diet samples under the hypothesis of their being as "reasonably representative" as any other. General hospitals exist in each of the selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected once every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the laboratory, each sample is homogenized, dried, and ashed prior to determination of stable calcium, potassium, strontium, and sodium.

The radiochemical analyses are based upon three basic procedures: chemical separations of strontium–89 and strontium–90; analysis of radium–226; and gamma spectrometry of the entire wet sample.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 2 for May through June 1965, and table 3 for July through August 1965.

Table 2. Estimated daily intake of radionuclides in California diets, May–June 1965 [a]

City	Kg/capita/day [b]	pCi/capita • day						Grams/capita • day			
		^{89}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	^{106}Ce-^{144}Ce	K [c]	Na	Ca	Stable Sr [d]
Bakersfield	2.1	9	0.5	84	6	0	0	2.5	3.3	0.0	0.001
Berkeley	2.7	18	0.3	82	7	5	3	2.8	5.3	0.9	NA
Bishop	1.8	11	0.3	65	7	0	0	2.2	3.7	0.6	0.001
Brawley	2.3	8	0.5	NA	NA	NA	NA	2.8	4.5	0.6	0.003
Crescent City	2.1	7	0.2	106	14	0	0	1.5	2.4	0.6	0.001
Eureka	1.7	16	0.5	77	4	0	4	4.3	3.1	0.8	NA
Fresno	2.5	12	0.9	0	0	0	0	2.5	4.7	1.2	NA
Los Angeles	2.7	11	0.4	78	5	0	1	2.3	3.0	0.1	0.001
Needles	2.2	9	0.4	67	6	0	6	2.0	3.0	0.7	0.001
Quincy	1.7	14	0.5	57	8	0	2	2.3	3.0	0.7	0.001
Redding	2.0	13	0.2	82	5	0	2	2.0	4.0	0.9	0.001
Sacramento	2.8	23	0.9	90	7	0	0	3.3	6.8	1.3	0.004
Salinas	2.4	16	0.8	63	7	0	0	4.0	8.0	1.2	0.008
San Bernardino	2.0	9	0.5	48	4	0	0	2.3	6.2	1.4	0.001
San Diego	2.2	14	0.7	55	0	0	1	3.0	5.0	1.0	0.006
San Luis Obispo	1.3	8	0.3	40	3	0	0	2.2	3.0	0.6	0.001
Santa Barbara	2.1	11	0.3	63	7	3	7	2.7	4.0	0.8	0.001
Santa Rosa	2.3	13	0.2	67	9	0	0	2.6	3.1	1.0	0.001
Susanville	1.6	12	0.3	71	10	0	0	2.0	5.0	0.6	0.001
Ukiah	2.0	17	1.0	88	11	0	0	2.4	2.3	1.5	0.001

[a] Based on analyses of hospital standard diets located in listed cities. Strontium-89 was not detectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
[d] Stable strontium consists of ^{88}Sr—82.7 percent; ^{87}Sr—7.0 percent; ^{86}Sr—9.8 percent; ^{84}Sr—0.5 percent; total—100 percent.
NA, no analysis performed.

Table 3. Estimated daily intake of radionuclides in California diets, July–August 1965 [a]

City	Kg/capita/day [b]	pCi/capita • day						Grams/capita • day			
		^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	^{141}Ce-^{144}Ce	K [c]	Na	Ca	Stable Sr [d]
Bakersfield	2.2	8	0.5	43	7	0	0	2.4	3.6	0.9	0.002
Berkeley	2.6	10	0.3	85	9	0	0	2.7	3.8	0.6	0.002
Bishop	1.7	10	1.2	62	6	0	0	2.0	3.0	0.9	0.001
Brawley	2.1	9	1.4	47	4	0	4	2.5	4.0	0.9	0.002
Crescent City	2.4	26	0.7	109	15	0	0	3.0	4.5	1.1	0.006
Eureka	2.2	18	0.8	77	13	0	0	2.8	4.0	1.3	0.003
Fresno	2.7	9	0.8	70	13	0	0	2.5	4.3	0.9	0.002
Los Angeles	2.2	6	0.7	48	13	0	4	2.2	3.4	0.8	0.002
Needles	2.0	10	0.9	48	4	0	3	2.1	3.1	0.8	0.008
Quincy	1.7	9	0.7	55	5	2	0	2.1	2.7	0.8	0.001
Redding	1.8	10	0.6	56	31	0	1	1.8	4.1	0.6	0.002
Sacramento	2.8	16	0.7	84	2	0	0	3.0	5.6	1.2	0.001
Salinas	2.3	10	0.7	61	5	0	0	3.0	4.8	0.8	0.002
San Bernardino	1.5	10	0.4	38	2	0	1	1.8	2.6	0.8	NA
San Diego	1.7	10	0.7	44	2	0	0	2.3	2.6	0.8	0.002
San Luis Obispo	1.4	12	0.7	35	3	0	6	2.2	2.3	0.8	0.001
Santa Barbara	2.2	15	0.8	61	2	0	0	2.6	4.0	1.0	0.006
Santa Rosa	2.4	13	0.5	68	7	0	0	2.3	3.0	1.3	NA
Susanville	2.0	11	0.3	80	9	0	3	2.3	4.7	0.7	0.001
Ukiah	2.4	15	0.4	71	8	3	8	2.6	3.6	1.4	NA

[a] Based or analyses of hospital standard diets located in listed cities. Strontium-89 was not detectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
[d] Stable strontium consists of ^{88}Sr—82.7 percent; ^{87}Sr—7.0 percent; ^{86}Sr—9.8 percent; ^{84}Sr—0.5 percent; total—100 percent.
NA, no analysis performed.

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action.

Average strontium–90 intake in the California diet for the May through June period varied from 7 to 23 pCi/capita/day. Cesium–137 intakes varied from 40 to 106 pCi/capita/day. Radium–226 intakes varied from 0.2 to 1.0 pCi/capita/day.

For the July through August sampling period the strontium–90 average varied from 6 to 26 pCi/capita/day. Cesium–137 intakes varied from 35 to 109 pCi/capita/day. Radium–226 intakes varied from 0.3 to 1.4 pCi/capita/day.

The observed intakes of strontium–90, cesium–137, and radium–226 in California diets were of such a magnitude that no actions were indicated based upon health implications.

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(*4*) RIVERA, J. Dietary intakes and body burdens of cesium–137. Rad Health Data 6:504–506 (September 1965).

(*5*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH, BUREAU OF RADIOLOGICAL HEALTH. Rad Health News 4:4 (October 1965) 2951 Berkeley Way, Berkeley 4, California.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1964	March and April 1965
July–October 1964	September 1965
November–December 1964	December 1965
January–April 1965	March 1966

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and/or treated (drinking) water. Most of these programs include determinations of gross alpha and gross beta radioactivity and/or specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Guides may be higher if total intake of radioactivity from all sources indicates that such intakes are within the limits recommended by FRC for control action. In the known absence [1] of strontium–90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below:

Program	Period reported	Last presented
Colorado River Basin Sampling Network	1962–1964	November 1965
Coast Guard Water Sampling Program	1964	November 1965
Drinking Water Analysis Program	1962	October 1965
California Water Sampling Program	January–June 1965	March 1966
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
Minnesota Surface Water Sampling Program	January–June 1965	February 1966
North Carolina Water Sampling Program	1964	November 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Washington Surface Water Sampling Program	July 1964–June 1965	May 1966

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962. Public Health Service Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents. U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

[1] Absence is taken to mean a neglibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium–90, respectively.

GROSS RADIOACTIVITY, DECEMBER 1965, AND STRONTIUM-90, APRIL–SEPTEMBER 1965, IN SURFACE WATERS OF THE UNITED STATES

Basic Data Program, Federal Water Pollution Control Administration

Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the Federal Water Pollution Control Administration on December 31, 1965. Beginning with the establishment of 50 sampling points, this system has been expanded to include 131 stations. These stations are operated jointly with other Federal, State, and local agencies, and with private industries. Samples are taken from surface waters of all major U.S. river basins for physical, chemical, biological, and radiological analyses. The system provides background information necessary for recognizing water quality trends and for determining current and general levels of surface water contamination and early detection of specific situations which may warrant more detailed evaluation. Complete data and exact sampling locations are published in annual compilations (*1–6*) or are available on request.

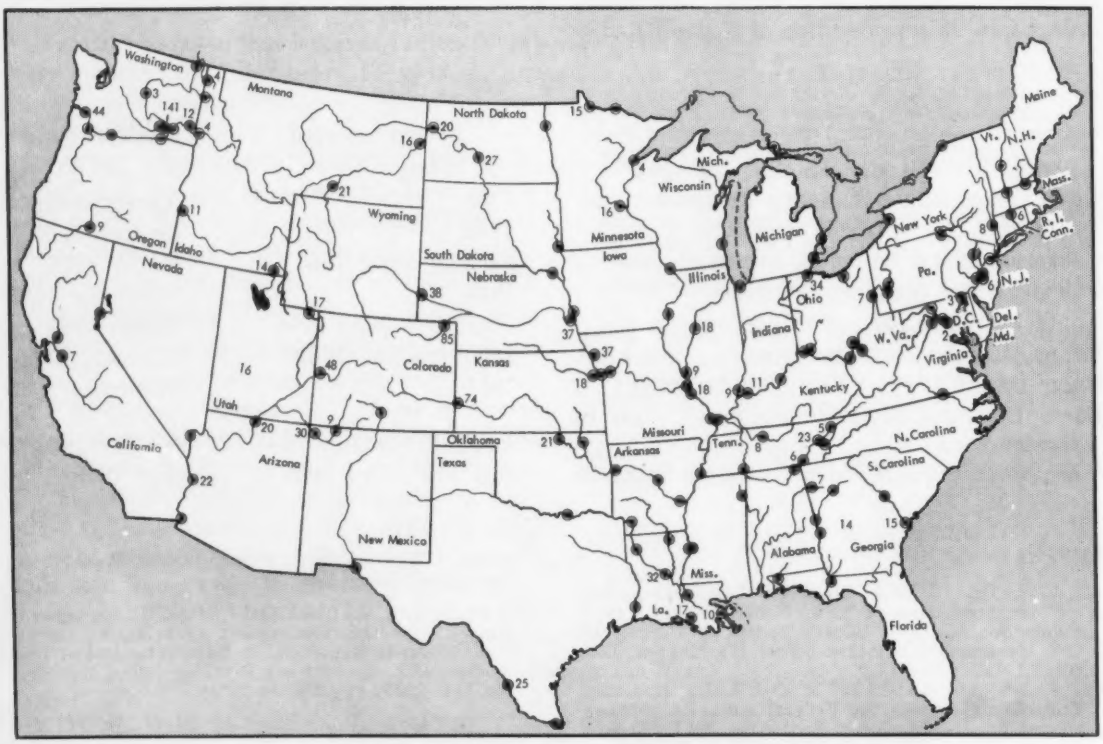

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, December 1965

Sampling procedures

The participating agencies collect 1–liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary. Presently, gross alpha and beta determinations are made either on monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are conducted at all newly established stations for the first year of operation. Weekly analyses are also scheduled for selected stations in an effort to detect short-term increases in radioactivity from current or recent nuclear tests or events.

Analytical methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*7*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Normally, samples are counted within 2 weeks following collection or within 1 week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. If a recount indicates that the original analysis was questionable, values based on the recount are recorded. All results are reported for the time of counting and are not extrapolated to the date of collection.

Results

Table 1 presents the current preliminary results of the alpha and beta analysis of U.S. surface waters. The stations on a river are arranged in the table according to their distance from the headwaters. The figures for gross alpha and beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pCi/liter. When all samples have zero pCi/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5, the mean is reported as <1 pCi/liter.

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations shown in figure 1, which gives the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station.

It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity, whereas fallout contributes primarily additional beta activity. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes (*9*).

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater, or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service Drinking Water Standards have already provided the basis for this assessment (*10*). Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

The following stations showed alpha values on dissolved solids in excess of 15 pCi/liter for

Table 1. Radioactivity in raw surface waters, December 1965

Station	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	4	5	9	1	1	2
Arkansas River:						
Coolidge, Kans.	13	61	74	3	28	31
Ponca City, Okla.	11	10	21	5	8	13
Atchafalaya River:						
Morgan City, La.	7	10	17	2	2	4
Bear River:						
Preston, Idaho	2	12	14	0	3	3
Big Horn River:						
Hardin, Mont.	1	20	21	0	9	9
Chena River:						
Fairbanks, Alaska	1	8	9	0	0	0
Clearwater River:						
Lewiston, Idaho	1	3	4	0	<1	<1
Clinch River:						
Clinton, Tenn.	0	5	5	0	0	0
Kingston, Tenn.	5	18	23	<1	<1	<1
Colorado River:						
Loma, Colo.	18	30	48	7	13	20
Page, Ariz.	<1	20	20	0	4	4
Parker Dam, Calif.-Ariz.	0	22	22	0	9	9
Columbia River:						
Wenatchee, Wash.	0	3	3	0	1	1
Pasco, Wash.	31	110	141	0	1	1
Clatskanie, Ore.	5	39	44	0	1	1
Connecticut River:						
Enfield Dam, Conn.	0	6	6	0	0	0
Coosa River:						
Rome, Ga.	2	5	7	1	0	1
Cumberland River:						
Cheatham Lock, Tenn.	0	8	8	0	0	0
Delaware River:						
Philadelphia, Pa.	2	4	6	1	0	1
Great Lakes:						
Duluth, Minn.	0	4	4	0	0	0
Green River:						
Dutch John, Utah	0	17	17	0	3	3
Hudson River:						
Poughkeepsie, N.Y.	1	7	8	0	0	0
Illinois River:						
Peoria, Ill.	7	11	18	2	3	5
Grafton, Ill.	3	6	9	1	3	4
Kansas River:						
De Soto, Kans.	1	17	18	0	4	4
Klamath River:						
Keno, Ore.	1	8	9	0	0	0
Maumee River:						
Toledo, Ohio	4	30	34	1	2	3
Mississippi River:						
St. Paul, Minn.	0	16	16	0	2	2
E. St. Louis, Ill.	3	15	18	1	3	4
New Orleans, La.	0	10	10	0	1	1
Missouri River:						
Williston, N. Dak.	3	17	20	0	5	5
Bismarck, N. Dak.	5	22	27	2	4	6
St. Joseph, Mo.	10	27	37	3	7	10
North Platte River:						
Henry, Nebr.	5	33	38	1	21	22
Ohio River:						
Toronto, Ohio	0	7	7	0	0	0
Cairo, Ill.	1	10	11	0	1	1
Pend Oreille River:						
Albeni Falls Dam, Idaho	<1	4	4	0	1	1
Platte River:						
Plattsmouth, Nebr.	14	23	37	4	8	12
Potomac River:						
Washington, D.C.	0	2	2	0	1	1
Rainy River:						
Baudette, Minn.	1	14	15	0	0	0
Red River, South:						
Alexandria, La.	9	23	32	3	1	4
Rio Grande:						
Laredo, Tex.	10	15	25	2	5	7
San Joaquin River:						
Vernalis, Calif.	2	5	7	2	1	3
San Juan River:						
Shiprock, N. Mex.	22	8	30	7	2	9
Savannah River:						
Port Wentworth, Ga.	4	11	15	0	0	0
Snake River:						
Payette, Idaho	1	10	11	0	4	4
Wawawai, Wash.	1	11	12	0	3	3
South Platte River:						
Julesburg, Colo.	17	68	85	4	43	47
Susquehanna River:						
Conowingo, Md.	0	3	3	0	0	0
Tennessee River:						
Chattanooga, Tenn.	1	5	6	0	0	0
Wabash River:						
New Harmony, Ind.	1	8	9	0	1	1
Yellowstone River:						
Sidney, Mont.	1	15	16	1	4	5
Maximum	31	110	141	7	43	47
Minimum	0	2	2	0	0	0

both November and December:

South Platte River: Julesburg, Colorado
North Platte River: Henry, Nebraska
Arkansas River: Coolidge, Kansas

The observed levels of radioactivity are entirely normal for these stations.

Pasco, Washington, showed a decline in dissolved beta radioactivity from about 150 pCi/liter in November to less than 150 pCi/liter in December.

Strontium–90 determinations and results

Beginning in 1959, strontium–90 analyses of the total solids in surface waters were made quarterly on 3-month composites of aliquots from weekly samples. Beginning in November 1962, the frequency of analysis was reduced to two quarterly samples per year at each sampling point except at those stations immediately below nuclear installations, where regular quarterly analyses were continued. The method used for determining strontium–90 is a modification of a procedure described by Harley (*8*). Yttrium–90, together with an yttrium carrier, is precipitated as yttrium oxalate. The latter is washed, dried, weighed, and counted in a low-background, anticoincidence, end-window proportional counter as a measure of the strontium–90 activity.

Table 2 presents the results of quarterly analyses of strontium–90 concentrations in U.S. surface waters for the second and third quarters of 1965. The stations are arranged in the table according to their distance from the headwaters.

Table 2. Quarterly strontium-90 concentrations in surface waters, April–September 1965

Station	Average concentration (pCi/liter)	
	Apr–June 1965	July–Sept 1965
Allegheny River:		
Pittsburgh, Pa	1.1	
Animas River:		
Cedar Hill, N. Mex		1.5
Apalachicola River:		
Chattahoochee, Fla		0.4
Arkansas River:		
Coolidge, Kans		3.3
Ponca City, Okla	2.2	
Fort Smith, Ark		2.9
Little Rock, Ark	2.0	
Pendleton Ferry, Ark	2.3	
Atchafalaya River:		
Morgan City, La		2.4
Bear River:		
Preston, Idaho		0.4
Big Horn River:		
Hardin, Mont	1.8	
Big Sioux River:		
Sioux Falls, S. Dak		2.5
Chattahoochee River:		
Atlanta, Ga	0.7	
Lanett, Ala		0.8
Columbus, Ga	1.1	
Chena River:		
Fairbanks, Alaska	0.4	
Clearwater River:		
Lewiston, Idaho		0.4
Clinch River:		
Clinton, Tenn		0.4
Kingston, Tenn	1.6	1.3
Colorado River:		
Loma, Colo	1.9	
Page, Ariz		0.7
Boulder City, Nev	1.9	
Parker Dam, Calif-Ariz		2.0
Yuma, Ariz	0.5	
Columbia River:		
Northport, Wash		0.9
Wenatchee, Wash	0.8	
Pasco, Wash	0.9	1.0
McNary Dam, Ore	0.7	0.8
Bonneville, Ore		0.5
Clatskanie, Ore	0.6	
Connecticut River:		
Wilder, Vt		0.5
Northfield, Mass	1.1	
Enfield Dam, Conn		1.0
Coosa River:		
Rome, Ga		0.1
Cumberland River:		
Cheatham Lock, Tenn		0.8
Cuyahoga River:		
Cleveland, Ohio		2.2
Delaware River:		
Martins Creek, Pa	0.6	
Trenton, N.J		0.7
Philadelphia, Pa	1.1	
Escambia River:		
Century, Fla	0.8	
Great Lakes:		
Duluth, Minn	0.7	
Sault Ste. Marie, Mich		0.4
Milwaukee, Wis	0.6	
Gary, Ind		0.7
Port Huron, Mich	1.0	
Detroit, Mich		1.2
Buffalo, N.Y	2.0	
Green River:		
Dutch John, Utah		1.6
Hudson River:		
Poughkeepsie, N.Y	1.1	
Illinois River:		
Peoria, Ill	1.6	
Kanawha River:		
Winfield Dam, W. Va		0.3
Kansas River:		
De Soto, Kans	1.9	
Klamath River:		
Keno, Ore	1.7	
Little Miami River:		
Cincinnati, Ohio		1.1
Maumee River:		
Toledo, Ohio	1.7	
Merrimack River:		
Lowell, Mass		0.7
Mississippi River:		
St. Paul, Minn		3.6
Dubuque, Iowa	4.0	
Burlington, Iowa		2.9
E. St. Louis, Ill	2.7	
Cape Girardeau, Mo		2.1
W. Memphis, Ark	2.3	
Vicksburg, Miss		1.7
Delta, La	2.2	
New Roads, La	2.3	
New Orleans, La		1.8
Missouri River:		
Williston, N. Dak	1.6	
Bismarck, N. Dak		2.1
Yankton, S. Dak	3.0	
Omaha, Nebr		2.5
St. Joseph, Mo	3.0	
Kansas City, Mo		2.6
Missouri City, Mo	1.9	
St. Louis, Mo		2.7
Monongahela River:		
Pittsburgh, Pa	0.9	
North Platte River:		
Henry, Nebr	2.2	
Ohio River:		
Toronto, Ohio	0.8	
Addison, Ohio		1.3
Huntington, W. Va	1.8	
Cincinnati, Ohio		1.1
Louisville, Ky	1.0	
Evansville, Ind		0.8
Cairo, Ill	1.4	
Ouachita River:		
Bastrop, La		1.3
Pend Oreille River:		
Albeni Falls Dam, Idaho	0.4	
Platte River:		
Plattsmouth, Nebr		2.9
Potomac River:		
Williamsport, Md	0.5	
Great Falls, Md		0.8
Washington, D.C		0.8
Rainy River:		
International Falls, Minn	3.9	
Baudette, Minn	2.8	
Red River, North:		
Grand Forks, N. Dak	6.1	5.2
Red River, South:		
Denison, Tex	3.7	4.1
Index, Ark	3.1	
Bossier City, La		1.3
Alexandria, La	2.0	
Rio Grande:		
Alamosa, Colo	1.2	
El Paso, Tex		1.0
Laredo, Tex	1.4	
Brownsville, Tex		1.3
Roanoke River:		
John H. Kerr Resr. & Dam, Va	1.1	
Sabine River:		
Ruliff, Tex		1.9
Sacramento River:		
Greens Landing, Calif		0.1
St. Lawrence River:		
Massena, N.Y		1.0
San Joaquin River:		
Vernalis, Calif	0.8	
San Juan River:		
Shiprock, N. Mex	2.0	
Savannah River:		
North Augusta, S.C		0.4
Port Wentworth, Ga	1.6	1.2
Schuylkill River:		
Philadelphia, Pa		0.9
Shenandoah River:		
Berryville, Va	0.6	
Ship Creek:		
Anchorage, Alaska		0.1
Snake River:		
Payette, Idaho	0.7	
Wawawai, Wash	0.4	
Ice Harbor Dam, Wash		0.1
South Platte River:		
Julesburg, Colo	1.8	
Spokane River:		
Post Falls Dam, Idaho		0.3
Susquehanna River:		
Sayre, Pa		0.4
Conowingo, Md	1.0	
Tennessee River:		
Lenoir City, Tenn	0.6	
Chattanooga, Tenn	1.0	0.6
Bridgeport, Ala	1.0	
Pickwick Landing, Tenn		0.7
Tombigbee River:		
Columbus, Miss		0.6
Truckee River:		
Farad, Calif	0.6	
Verdigris River:		
Nowata, Okla	2.7	
Wabash River:		
New Harmony, Ind	1.2	
Willamette River:		
Portland, Ore	0.2	
Yakima River:		
Richland, Wash		0.1
Yellowstone River:		
Sidney, Mont		1.5
Maximum	6.1	5.2
Minimum	0.2	0.1

While there are no standards for strontium–90 activity of total solids in surface waters, the Public Health Service Drinking Water Standards set the limit for approval of a drinking water supply containing strontium–90 at 10 pCi/liter. During the second and third quarters of 1965, this concentration was not reached in raw surface waters. Comparison between the two quarters is not feasible at all sampling locations due to fluctuations in sampling frequencies. Comparison with results prior to October 1964 should take into consideration an instrument recalibration which resulted in a lowering of strontium–90 values by 15 percent (*11*).

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RADIOACTIVITY IN NEW YORK SURFACE WATER JUNE–DECEMBER 1965

Division of Environmental Health Service, State of New York Department of Health

The New York Department of Health began a program in 1955 to determine the amount of radioactivity in water used for public consumption. This radioactivity in water may arise from any one or a combination of the following sources: the natural mineral content of water (background), atmospheric fallout, or nuclear industry operations. Water samples are obtained from 45 locations for gross beta analysis (figure 1). Table 1 gives the sampling frequency and type of sample. Larger size samples are collected at selected locations for strontium–90 analysis.

Analytical procedures

Beta activity concentrations are determined by evaporating a known volume of water to dryness and counting in an end-window, gas-flow proportional counter.

For strontium–89 and strontium–90 determinations, a measured volume of water is passed through an ion exchange column. The strontium is then eluted from the resin, concentrated, and counted in a low background, end-window, gas-flow proportional counter. Successive countings at 2-day intervals facilitate the determination of the strontium–90 and strontium–89 concentrations.

Discussion and results

The observed gross beta activity concentrations in New York surface water for June-December 1965 are given in table 1. It should be noted that the Cohoes gross beta results are for a raw water sample, while the Cohoes radiostrontium results are for a finished water.

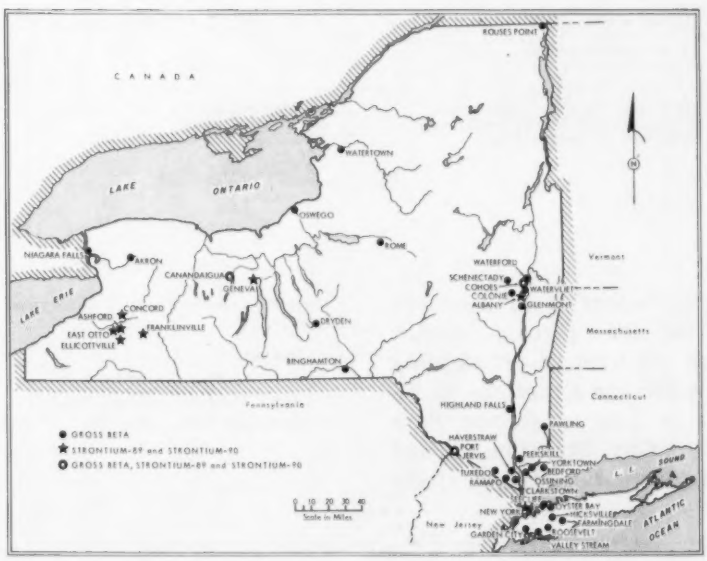

Figure 1. New York water sampling locations

Table 1. Gross beta activity concentrations in New York raw surface water June–December 1965

Location	Sampling frequency	Concentration, pCi/liter						
		June	July	Aug	Sept	Oct	Nov	Dec
Akron (Murder Creek)	BD	8	9	8	7	7	7	9
Bedford (Byram Lake)	M	10	7	6	7	7		9
Binghamton (Binghamton Water Supply)	Q	4						
Canandaigua (Canandaigua Lake)	SA	5						
Clarkstown (Congers Lake)	Q	13		16				9
(Lake De Forest)	Q	7		7				6
Cohoes (Mohawk River)	D	6	7	7	6	7	6	4
Colonie (Patroon Creek)	SA			6				
Concord (18 Mile Creek)	SA			150				
Dryden (Cayuga Lake)	SA							1
Farmingdale (Well No. 1)	SA	2						
Garden City (Well No. 2)	SA	3						
Glenmont (Hudson River)	D	8	6	6	6	5	5	4
Haverstraw (Letchworth Village Reservoir)	Q	3		3				2
Hicksville (Well No. 4)	SA	2						
Highland Falls (Bog Meadow Brook)	M	4	8	3	4	4	3	3
Lansing (Airport Well)	SA	<1						2
(East Stream-Cayuga Lake)	SA	6						14
(West Stream-Cayuga Lake)	SA	3						3
(Kahrs Well)	SA	2						
(Neigh Well)	SA	1						3
(Research Park Well)	SA	2						2
(Shively Well)	SA	<1						2
Niagara Falls (East Branch-Niagara River)	M	8	9	7				
(West Branch-Niagara River)	M	7	8	8				
Ossining (Hudson River)	D	41	53	44	57	44	25	15
(Indian Brook Reservoir)	M	8	6	8	7	6		6
Oswego (Lake Ontario)	M	6	4	4	3	5	4	4
Oyster Bay (Lake Ontario)	SA	2						
Pawling (Pond at United Nuclear)	M	6	5	5				
Peekskill (Camp Field Water Supply)	M	4	3	7	13	2		22
(Hudson River)	D	25	35	35	52	36		23
Port Jervis (Delaware River)	Q	4			3			
Ramapo (Hillburn Reservoir)	Q	3		4				1
Rome (Fish Creek)	BD	5	5	5	4	5	4	4
Roosevelt	SA	9						
Rouses Point (Lake Champlain)	Q		5					
Schenectady (Mohawk River)	C	4	5	5	5	5	4	5
Sea Cliff (Mohawk River)	SA	4						
Tuxedo (Indian Kill)	M	5	24	5	9	4	4	4
Valley Stream	SA	1						
Waterford (Hudson River)	C	6	6	5	5	4	4	3
Watertown (Black River)	BD	6	7	5	5	7	6	4
Watervliet (French Mills Reservoir)	BD	5		3	4	4	5	5
Yorktown (Croton Reservoir)	M	7	6	5	4	3		3

BD, bi-weekly composite of daily grab samples
D, weekly composite of daily grab sample
C, continuous bleed-off, analyzed weekly
M, monthly grab sample
Q, quarterly grab sample
SA, semiannual grab sample

The average concentrations of strontium–89 and strontium–90 for June through August 1965 were less than the level of detectability (3 pCi/liter) except for one strontium–90 result of 6 pCi/liter in July at Jerome Park Reservoir in New York City. Strontium–89 and strontium–90 reports were discontinued at the end of August.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July 1963–June 1964	December 1964
June 1964–December 1964	September 1965
January–June 1965	January 1966

RADIOSTRONTIUM IN TAP WATER MAY AND JULY–NOVEMBER 1965[1]

Health and Safety Laboratory, U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium–90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium–137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Cesium–137 to strontium–90 ratios and strontium–90 concentrations in New York City tap water for May and July through November 1965 are presented in table 1. These results appear graphically in figure 1.

A decreasing trend has been observed in the strontium–90 concentrations since the July 1963 peak. The maximum strontium–90 concentra-

[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL–171. This report is available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 528S Port Royal Road, Springfield, Virginia 22131.

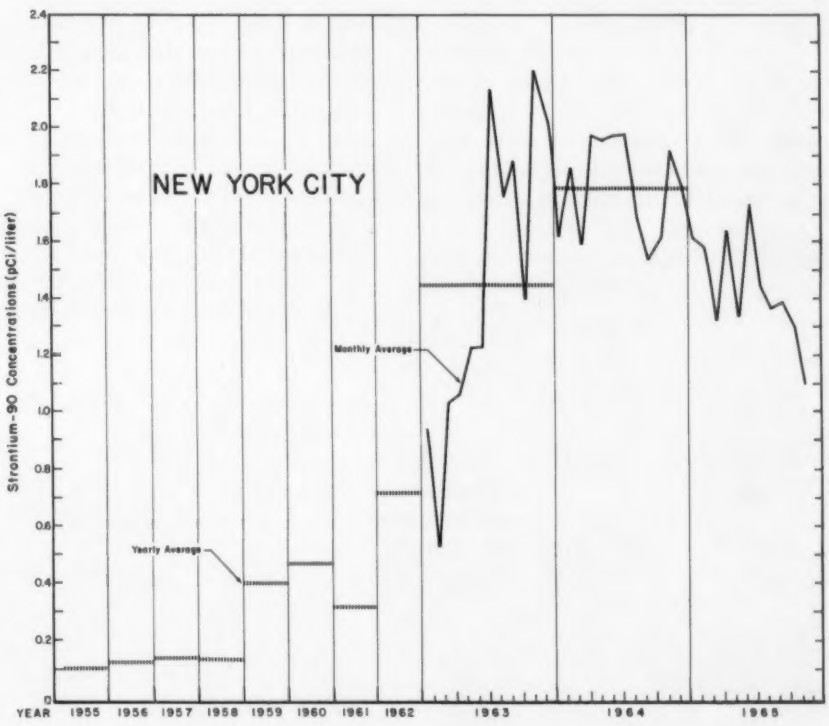

Figure 1. Strontium–90 concentrations in New York City tap water

tions observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

Table 1. Radiostrontium in New York City tap water May and July–November 1965

Month 1965	New York City	
	Strontium-90 [a] (pCi/liter)	Cesium-137/ strontium-90
May	1.34	0.18
July	1.44	0.19
August	1.36	0.15
September	1.38	0.12
October	1.30	NR
November	1.10	NR

[a] Approximately 100 liters per sample
NR, no ratio reported

Previous coverage in *Radiological Health Data:*

Period	Issue
January–April 1962	September 1962
March–June 1962	January 1963
July-December 1962	July 1963
January–April 1963	January 1964
May–October 1963	April 1964
November 1963–December 1964	June 1965
January–June 1965	December 1965

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Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period reported	Last presented
Mexican Air Monitoring Program	November 1965	March 1966
National Air Sampling Network	October-December and Annual Summary 1965	April 1966
HASL Fallout Network	January-June 1965	May 1966

1. Radiation Surveillance Network February 1966

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analysis procedures was presented in the December 1965 issue of *Radiological Health Data.*

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during February 1966. Time profiles of gross beta in air dating from 1960 for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on 227 air samples. Traces of longer-lived fission products were identified in these samples.

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta activity in surface air and precipitation, February 1966

Station location		Air surveillance						Precipitation	
		Number of samples		Gross beta activity, pCi/m³			Last profile in *RHD & R*	Total depth (mm)	Total deposition (nCi/m²)[a]
		Air	Pptn	Maximum	Minimum	Average [a]			
Ala:	Montgomery	28	8	0.14	<0.10	<0.11	Feb 66	215	<43
Alaska:	Adak	28	NS	0.11	<0.10	<0.10	Jun 66		
	Anchorage	18	3	0.17	<0.10	<0.11	Mar 66	6	<1
	Attu Island	NS	NS				Oct 65		
	Fairbanks	11	3	<0.10	<0.10	<0.10	Apr 66	26	<5
	Juneau	17	13	<0.10	<0.10	<0.10	May 66	137	<28
	Kodiak	10	NS	0.13	<0.10	<0.10	May 66		
	Nome	NS	NS				Dec 65		
	Point Barrow	25	NS	0.13	<0.10	<0.10	Nov 65		
	St. Paul Island	26	NS	<0.10	<0.10	<0.10	Jan 66		
Ariz:	Phoenix	27	NS	0.19	<0.10	<0.12	May 66	50	<10
Ark:	Little Rock	21	1	0.11	<0.10	<0.10	Mar 66	82	<17
Calif:	Berkeley	19	7	0.20	<0.10	<0.11	May 66	37	<7
	Los Angeles	19	2	0.15	<0.10	<0.11	Dec 65		
C. Z:	Ancon	14	NS	<0.10	<0.10	<0.10	May 66		
Colo:	Denver	24	3	0.17	<0.10	<0.11	May 66	17	<4
Conn:	Hartford	27	9	0.11	<0.10	<0.10	Apr 66	66	<13
Del:	Dover	18	NS	0.11	<0.10	<0.10	Feb 66		
D. C:	Washington	28	8	0.11	<0.10	<0.10	Nov 65	59	<12
Fla:	Jacksonville	26	10	0.13	<0.10	<0.10	Mar 66	154	<31
	Miami	27	3	0.13	<0.10	<0.10	Apr 66	103	<21
		NS	NS				Jan 66		
Ga:	Atlanta	26	NS	<0.10	<0.10	<0.10	Feb 66		
Guam:	Agana	28	5	<0.10	<0.10	<0.10	Oct 65	113	<23
Hawaii:	Honolulu	23	2	0.53	<0.10	<0.12	Oct 65	39	<6
Idaho:	Boise	24	1	0.16	<0.10	<0.11	Nov 65	70	<14
Ill:	Springfield	28	7	0.16	<0.10	<0.10	Jan 66	70	<14
Ind:	Indianapolis	26	3	0.18	<0.10	<0.10	Jun 66	18	<4
Iowa:	Iowa City	28	2	0.16	<0.10	<0.10	Mar 66	13	<3
Kans:	Topeka	26	6	0.12	<0.10	<0.10	Nov 65	35	<7
Ky:	Frankfort	27	11	0.13	<0.10	<0.10	Nov 65	255	<51
La:	New Orleans	26	5	<0.10	<0.10	<0.10	Dec 65	119	<24
Maine:	Augusta	24	NS	<0.10	<0.10	<0.10	Jun 66	50	<10
	Presque Isle	17	5	0.12	<0.10	<0.10	Apr 66		
Md:	Baltimore	15	NS	0.11	<0.10	<0.10	Oct 65	48	<10
	Rockville	28	6	0.16	<0.10	<0.11	Feb 66	39	<8
Mass:	Lawrence	27	7	<0.10	<0.10	<0.10	Sep 65		
	Winchester	28		0.12	<0.10	<0.10	Oct 65	41	<8
Mich:	Lansing	18	5	<0.10	<0.10	<0.10	Feb 66	145	<29
Minn:	Minneapolis	24	6	0.12	<0.10	<0.10	Dec 65	64	<13
Miss:	Jackson	28	6	0.11	<0.10	<0.10	Jan 66		
Mo:	Jefferson City	27	4	0.19	<0.10	<0.11	Jun 66	10	<2
Mont:	Helena	15	NS	0.11	<0.10	<0.10	Jan 66		
Nebr:	Lincoln	26	NS	0.19	<0.10	<0.12	Apr 66		
Nev:	Las Vegas	19	NS	0.13	<0.10	<0.10	Nov 65	23	<5
N. H:	Concord	27	6	0.14	<0.10	<0.10	Dec 65		
N. J:	Trenton	28	6	0.17	<0.10	<0.11	Jun 66	14	<3
N. Mex:	Santa Fe	19	7	0.13	<0.10	<0.10	Jan 66	53	<11
N. Y:	Albany	26	NS	0.17	<0.10	<0.10	Jun 66		
	Buffalo	27	NS	<0.10	<0.10	<0.10	Sep 65	110	<22
	New York	28	8	0.12	<0.10	<0.10	Jun 66		
N. C:	Gastonia	27	2	<0.10	<0.10	<0.10	Nov 65	7	<1
N. Dak:	Bismarck	18	NS	<0.10	<0.10	<0.10	Feb 66		
Ohio:	Cincinnati	28	5	0.22	<0.10	<0.12	Dec 65	41	<8
	Columbus	28	6	0.13	<0.10	<0.10	Apr 66	38	<8
	Painesville	27	4	<0.10	<0.10	<0.10	Oct 65	34	<7
Okla:	Oklahoma City	25	4	<0.10	<0.10	<0.10	Apr 66	44	<9
	Ponca City								
Ore:	Portland	28	11	0.16	<0.10	<0.11	Jan 66	43	<9
Pa:	Harrisburg	26	3	<0.10	<0.10	<0.10	Jan 66	47	<10
P. R:	San Juan	23	1	0.25	<0.10	<0.11	Dec 65	15	<3
R. I:	Providence	27	5	<0.10	<0.10	<0.10	Oct 65	63	<13
S. C:	Columbia	24	6	0.12	<0.10	<0.10	Sep 65	77	<15
S. Dak:	Pierre	26	1	<0.10	<0.10	<0.10	May 66	13	2
Tenn:	Nashville	27	9	<0.10	<0.10	<0.10	Oct 65	95	<19
Tex:	Austin	28	7	0.17	<0.10	<0.11	Feb 66	65	<13
	El Paso	27	2	0.19	<0.10	<0.12	Nov 65	9	<2
Utah:	Salt Lake City	26	7	0.15	<0.10	<0.11	Dec 65	41	<8
Vt:	Barre	27	6	0.11	<0.10	<0.10	Mar 66	49	<10
Va:	Richmond	28	7	0.12	<0.10	<0.10	Mar 66	74	<15
Wash:	Seattle	28	14	<0.10	<0.10	<0.10	Mar 66	43	<9
	Spokane	27	2	<0.10	<0.10	<0.10	Feb 66	7	<1
W. Va:	Charleston	26	9	<0.10	<0.10	<0.10	Sep 65	57	<11
Wis:	Madison	27	4	<0.10	<0.10	<0.10	Mar 66	28	<6
Wyo:	Cheyenne	28	2	0.16	<0.10	<0.11	Apr 66	5	<1
Network summary		1,732	295	0.53	<0.10	<0.10		59	<12

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

NS, no air or precipitation sample collected.

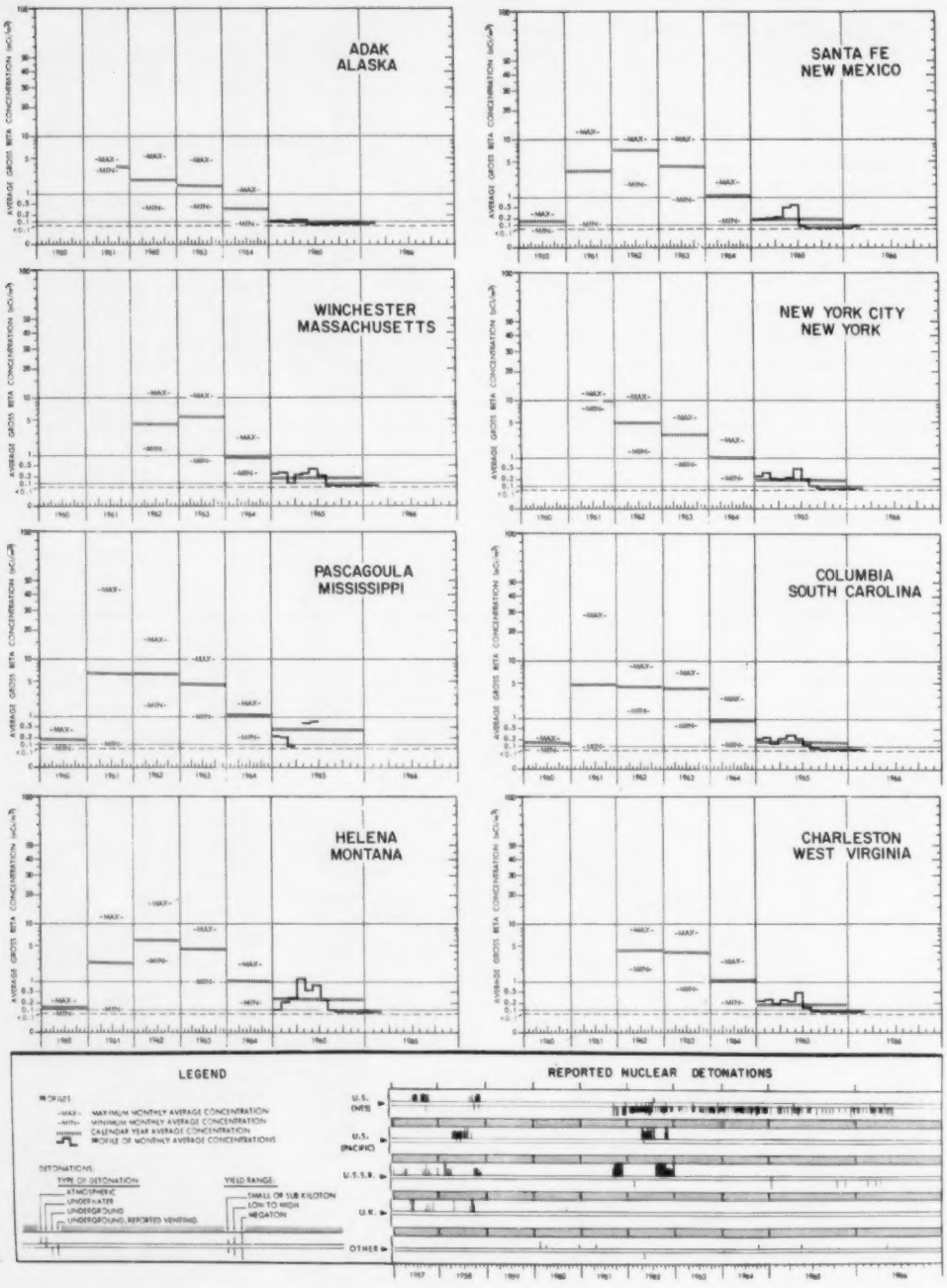

Figure 2. Monthly and yearly profiles of beta activity in air Radiation Surveillance Network, 1960–February 1966

2. Canadian Air and Precipitation Monitoring Program, February 1966[1]

Radiation Protection Division, Department of National Health and Welfare
Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data.*

[1] Prepared from information and data in the October 1965 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for February 1966 are presented in table 2.

Table 2. Canadian gross beta activity in surface air and precipitation, February 1966

Station	Air surveillance				Precipitation measurements	
	Number of samples	Activity, pCi/m³			Average concentration (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	28	0.2	0.0	0.1	177	0.9
Coral Harbour	28	0.2	0.0	0.1	28	0.5
Edmonton	28	0.2	0.0	0.1	47	0.5
Ft. Churchill	28	0.1	0.0	0.1	39	0.5
Ft. William	27	0.2	0.1	0.1	50	0.7
Fredericton	27	0.1	0.0	0.1	16	1.2
Goose Bay	27	0.2	0.0	0.1	13	0.4
Halifax	28	0.1	0.0	0.1	41	2.1
Inuvik	28	0.2	0.1	0.1	41	0.4
Montreal	28	0.2	0.0	0.1	21	1.3
Moosonee	28	0.1	0.0	0.1	18	0.7
Ottawa	28	0.1	0.0	0.1	23	0.7
Quebec	27	0.1	0.0	0.1	47	2.1
Regina	28	0.2	0.1	0.1	38	0.3
Resolute	28	0.2	0.0	0.1	NS	NS
St. John's, Nfld	28	0.1	0.0	0.1	17	1.1
Saskatoon	28	0.2	0.0	0.1	37	0.4
Sault Ste. Marie	28	0.1	0.0	0.1	24	1.4
Toronto	28	0.1	0.0	0.1	25	1.1
Vancouver	28	0.1	0.0	0.0	41	2.0
Whitehorse	28	0.2	0.0	0.1	20	0.4
Windsor	28	0.2	0.0	0.1	21	0.9
Winnipeg	28	0.2	0.1	0.1	97	1.0
Yellowknife	28	0.2	0.1	0.1	T	0.4
Network summary		0.2	0.0	0.1	40	0.9

NS, no sample collected.
T, trace amount observed, below quantifiable level.

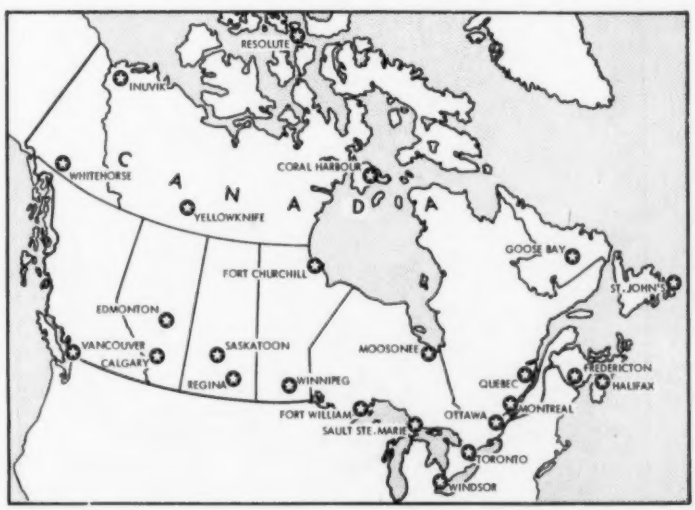

Figure 3. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program February 1966

Pan American Health Organization and U.S. Public Health Service

Gross beta activity in air is monitored by countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The locations of air sampling stations are shown in figure 4.

The February 1966 air monitoring results from the participating countries are given in table 3.

Table 3. PAHO gross beta activity in surface air and precipitation, February 1966

Station location	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	15	<0.10	<0.10	<0.10
Chili: Santiago	21	<0.10	<0.10	<0.10
Jamaica: Kingston	21	<0.10	<0.10	<0.10
Peru: Lima	22	<0.10	<0.10	<0.10
Venezuela: Caracas	17	<0.10	<0.10	<0.10
West Indies: Trinidad	16	<0.10	<0.10	<0.10
Pan American summary	112	<0.10	<0.10	<0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

Figure 4. Pan American Air Network sampling stations

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(*1*) LOCKHART, L. B., JR., and R. L. PATTERSON, JR. Intercalibration of the major North American networks employed in monitoring airborne fission products, NRL Report 6025, Naval Research Laboratory, Washington, D.C. 20390 (December 1963); summarized in *Radiological Health Data*, 5:12–15 (January 1964).

(*2*) RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. Division of Radiological Health, Public Health Service, Washington, D.C. 20201 (Distribution by official request).

(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1959 on the Radioactive Fallout Study Program. CNHW–RP–3, Department of National Health and Welfare, Ottawa, Canada (May 1960).

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(*6*) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program. RPD–11, Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*7*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada. RPD–21, Department of National Health and Welfare, Ottawa, Canada (August 1962).

Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

STRONTIUM-90 IN HUMAN BONE, FIRST QUARTER 1965

Division of Radiological Health
Public Health Service

To obtain data on the concentration of strontium–90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in the United States in late 1961. The target population includes children and young adults up to 25 years of age. Since strontium–90 in measurable amounts has been present in the global environment for more than a decade and major calcium accretion ceases by age 17 or 18, persons over 25 years old are of limited interest in the program. This has been confirmed by analyses of selected samples of people in older age groups, the results having shown their bone strontium–90 content to be low and age-independent (*1*).

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it is difficult to get so large a sample from infants and children under 5 years of age.

Most specimens received to date have been vertebrae and ribs. Efforts to collect long bones for comparison to United Kingdom data have not been successful.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Division of Radiological Health, at Winchester, Massachusetts. The collection and preparation of samples are described elsewhere (*2*). Strontium–90 is measured by TBP extraction of its yttrium daughter, which is precipitated as the oxalate. The strontium–90 content is then calculated from the yttrium–90 activity (*3*).

The results for strontium–90 in individual bones from persons dying during the first quarter of 1965 are presented in table 1. All data are summarized in table 2. The data are reported as picocuries of strontium–90 per gram of ash (the primary determination), per gram of calcium (for comparison with other data and for purposes of model development), and per gram of bone (as a rough indication of dose). Two-sigma counting errors are reported for the ash concentration. Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–4*).

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(*1*) RIVERA, J. Strontium–90 in human vertebrae, 1962–1963. Rad Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium–90 content of human bones, 1961–1963. Rad Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples chemical and radiochemical procedures NERHL 64–1 (April 1964).

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Table 1. Strontium-90 in human bone, first quarter 1965

Location of sample by region and State	Age at death (years) [a]	Sex	Bone type [b]	Strontium-90, pCi/g of:			
				Ash	2σ error	Ca	Bone
Northeast:							
Massachusetts	2	F	V	3.15	0.25	8.90	0.34
	4	M	V	1.12	0.16	3.09	0.10
	5	M	V	1.38	0.13	3.94	0.10
	7	M	V	1.11	0.18	3.19	0.09
	14	F	V	1.43	0.08	3.79	0.18
	19	M	V	0.86	0.07	2.29	0.13
	20	M	V	1.01	0.09	2.73	0.12
	21	F	V	0.61	0.08	1.63	0.10
	24	M	V	0.70	0.06	1.81	0.10
	9	M	V	1.15	0.10	3.15	0.12
New York	11	M	V	1.16	0.10	3.17	0.10
	16	M	V	1.07	0.08	2.80	0.13
	17	M	V	0.93	0.09	2.47	0.09
	23	M	V	0.54	0.05	1.40	0.08
Pennsylvania	23	M	V	0.90	0.06	2.22	0.13
Rhode Island	2	M	V, R	1.72	0.18	4.53	0.17
Central:							
Michigan	2	F	V	2.06	0.18	5.68	0.19
Minnesota	8	M	V	0.99	0.11	2.75	0.10
	22	M	V	0.51	0.07	1.42	0.08
Missouri	16	M	V, R	1.09	0.07	2.69	0.27
	19	F	V	0.85	0.08	2.15	0.17
Ohio	2	M	V	1.86	0.14	5.06	0.18
	2	M	V	1.17	0.14	3.36	0.08
	3	M	V	1.30	0.11	3.63	0.10
	18	M	V	0.88	0.07	2.32	0.10
	23	M	V	0.59	0.06	1.52	0.08
	25	M	V	0.57	0.07	1.42	0.09
Wisconsin	4 mo.	M	V	1.97	0.20	5.48	0.16
	8 mo.	F	V	1.75	0.23	4.10	0.14
	1	M	V	1.62	0.14	4.38	0.14
	1	M	V	1.20	0.15	3.25	0.09
	2	F	V	1.88	0.18	5.69	0.14
	3	M	V	1.58	0.12	4.28	0.13
	4	F	V	1.35	0.13	3.71	0.11
	4	F	V	0.81	0.08	2.33	0.06
	5	F	V	0.94	0.13	2.54	0.08
	8	F	V	0.83	0.08	2.30	0.09
	8	M	V	0.50	0.05	1.39	0.04
	9	M	V	0.84	0.09	2.31	0.09
	13	F	V	0.56	0.05	1.58	0.06
	15	M	V	0.68	0.06	1.84	0.08
Delta:							
Louisiana	4 mo.	M	V, R	1.67	0.14	4.38	0.20
	3	M	V, R	1.66	0.14	4.53	0.15
	3	F	V, R	1.36	0.14	3.68	0.12
	8	F	V	1.08	0.09	2.92	0.10
	13	M	V	1.28	0.09	3.49	0.13
	18	F	V, R	1.12	0.10	2.94	0.17
	22	F	R	0.40	0.06	0.99	0.07
	25	M	R	0.49	0.05	1.22	0.10
Northwest:							
Alaska	17	F	R	1.86	0.20	4.71	0.63
	22	F	R	0.51	0.10	1.28	0.16
Washington	7	M	V	1.01	0.14	2.77	0.10
	13	F	V	1.60	0.14	4.37	0.18
Southwest:							
California	6 mo.	M	V, R, S	0.49	0.08	1.53	0.03
	1	M	V, S	0.97	0.09	2.69	0.08
	5	M	V	0.76	0.11	2.21	0.05
	5	M	V, R	0.64	0.08	1.81	0.54
	5	M	V	0.50	0.08	1.41	0.05
	8	M	V	0.48	0.06	1.33	0.04
Texas	4	M	V	0.88	0.15	2.47	0.07
	10	F	V	0.86	0.13	2.34	0.09
	17	F	V	0.55	0.07	1.46	0.07
	24	F	V	0.54	0.06	1.47	0.06
	24	F	V	0.36	0.06	0.99	0.03

[a] Age given as of last birthday prior to death for ages greater than 1 year.
[b] Type of bone: V, vertebra
S, sternum
R, rib

Table 2. Strontium-90 in human bone samples for 5-year groups 1961–1964 and first quarter 1965

Age group [a]	Year of death [b]	Number	Strontium-90/calcium, pCi/g		
			Mean	Minimum	Maximum
0–4 years	1961	3	2.7	1.8	3.4
	1962	50	3.3	0.8	9.7
	1963	44	4.5	1.0	13.0
	1964	67	4.4	1.0	8.7
	1965, first quarter	21	4.1	1.5	8.9
5–9 years	1961	1	2.7	—	—
	1962	33	2.7	1.0	9.4
	1963	43	3.9	1.8	9.1
	1964	64	3.6	1.2	7.0
	1965, first quarter	14	2.4	1.3	3.9
10–14 years	1961	4	1.8	1.2	2.8
	1962	28	2.1	0.8	3.5
	1963	47	2.9	1.1	9.0
	1964	56	3.1	0.9	5.7
	1965, first quarter	6	3.1	1.6	4.4
15–19 years	1961	0	—	—	—
	1962	31	2.2	0.9	4.6
	1963	73	2.6	1.0	7.0
	1964	58	2.9	1.2	8.0
	1965, first quarter	11	2.5	1.5	4.7
20–24 years	1961	0	—	—	—
	1962	29	1.8	0.9	3.5
	1963	61	2.2	0.9	5.0
	1964	52	2.2	0.8	4.3
	1965, first quarter	10	1.6	1.0	2.7

[a] Ages taken as of last birthday prior to death
[b] Or surgical procedure

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Brookhaven National Laboratory and the Rocky Flats Plant.

[1] Part 20, "Standards for Protection against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20442, on a subscription basis at $3.50 for 3 years.

1. Brookhaven National Laboratory
July–December 1965

Associated Universities, Inc.
Upton, New York

The Brookhaven National Laboratory (BNL) operations may affect the environmental levels of radiation in three ways: (1) by discharge of coolant air from the graphite research reactor, (2) by radiation from an ecology forest gamma source, and (3) by the discharge of low-level radioactive liquid wastes into a small stream that forms one of the headwaters of the Peconic River (figure 1).

Area monitoring

The radioactivity in the discharge coolant air is almost entirely due to argon–41, a beta-gamma emitter. Because exposure to argon–41 is due to external gamma, the monitoring is performed by measuring the exposure rate in milliroentgens per week (mR/wk) rather than the concentration in air.

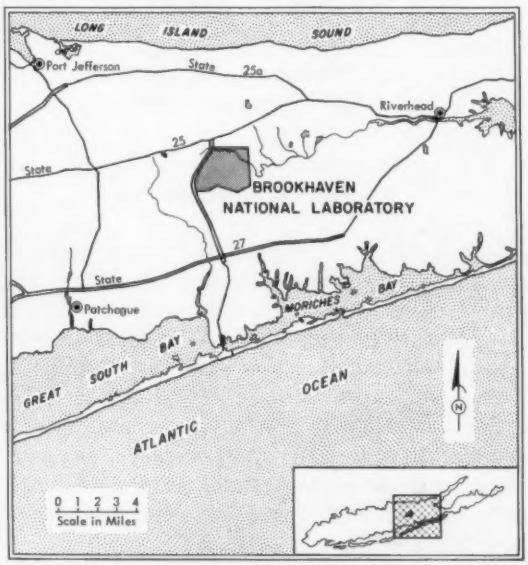

Figure 1. Brookhaven National Laboratory and surrounding area

Late in 1961, a 10,000-curie cesium–137 gamma source was installed in the ecology forest about 800 meters equidistant from the north and east boundaries (*1*). The radiation levels resulting from the graphite research reactor effluent and the ecology forest source are monitored continuously by four stations located at the site boundary (figure 2).

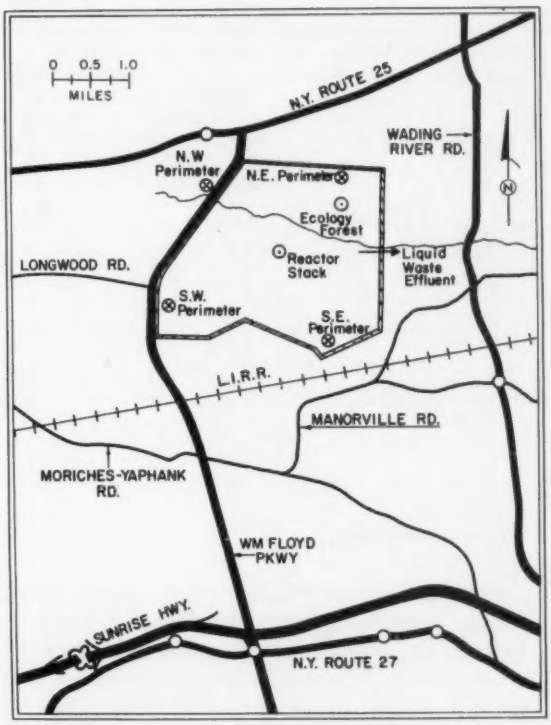

Figure 2. Brookhaven National Laboratory monitoring station locations

Radiation levels at the northeast perimeter are somewhat greater than at other monitoring stations due to the ecology forest source. However, the radiation levels at this location are within the AEC standard. The standard established by AEC is 0.5 rem/year for individuals in the population. The average weekly radiation levels at the Brookhaven National Laboratory site boundary, due to laboratory operations, are given in table 1.

Values of radiation background levels undisturbed by laboratory operations have been included in table 1 for purposes of comparison.

[1] Part 20, "Standards for Protection against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

The ion chambers used in making these background level measurements are positioned 2 feet above the monitoring station roof. Measurements made in this manner are in close agreement with those made at 3 feet above the ground surface in the vicinity of the stations.

Table 1. External gamma levels at BNL site boundary July–December 1965 and calendar year 1965

Period	Average exposure rates, mR/wk			
	Northwest perimeter	Southwest perimeter	Southeast perimeter	Northeast perimeter
Gamma exposure from laboratory operations:				
Second half 1965	0.26	0.33	0.38	2.65
July	0.03	0.04	0.08	3.07
August	0.35	0.26	0.17	3.42
September	0.33	0.57	0.29	3.76
October	0.49	0.25	0.82	2.09
November	0.12	0.55	0.48	1.84
December	0.19	0.33	0.49	1.53
First half 1965	0.23	0.13	0.61	2.27
Calendar year 1965	0.24	0.23	0.49	2.46
Average undisturbed background	2.21	2.04	2.25	2.35

Water monitoring

The liquid waste effluent from the laboratory sewage processing plant is monitored continuously at the point where it is discharged to the small stream. The values of concentration and activity in the stream where it leaves the site are computed on the basis of continuous measurements of the stream flow rate.

The gross concentration and amount of radioactivity in the laboratory's liquid waste effluent, as it leaves the site, are shown in table 2. Analysis of composite samples of the effluent has shown that, on the average, no more than 20 percent of the activity consists of strontium–90 and that no appreciable amounts of radioactive iodine or radium and other bone-seeking isotopes are present. Thus, were the BNL waste effluent to be used as drinking water, the applicable limit on the concentration, in accordance with the regulations of the Atomic Energy Commission, would be 1,000 picocuries per liter, averaged over a period of 1 year. However, the effluent does not enter directly into any drinking water supply and it undergoes considerable additional dilution as it progresses downstream. The average concentration value for the year, 38 picocuries per liter, is small relative to the permissible concentration.

Table 2. Gross beta activity in BNL liquid waste effluent July–December 1965 and calendar year 1965

Period	Average beta concentration (pCi/liter)	Total beta activity discharged (mCi)
Second half 1965	36	19.3
July	34	3.2
August	29	3.3
September	28	2.6
October	34	3.0
November	31	2.5
December	65	4.8
First half 1965	41	22.4
Calendar year 1965	38	41.8

Recent coverage in *Radiological Health Data:*

Period	Issue
July–December 1961	June 1962
January–June 1962	January 1963
July 1962–June 1963	February 1964
July 1963–June 1964	December 1964
July–December 1964	June 1965
January–June 1965	December 1965

2. Rocky Flats Plant July–December 1965

Dow Chemical Company
Golden, Colorado

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location relative to population centers is shown in figure 3. To assure properly controlled release of radioactive materials to the environment, periodic samples of water, air, and vegetation are analyzed for gross alpha activity. The most abundant radioactive material involved in the process is plutonium.

The plant is located about 15 miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized Front Range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

Air

Continuous 24-hour air samples were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner School, Golden, Denver, and Westminster. The gross alpha activities which are shown in table 3 as monthly averages are believed due to naturally occurring materials.

Table 3. Long-lived alpha activity in particulates in air, RFP

Period	Average alpha concentration (pCi/m^3)
July	<0.006
August	<0.006
September	0.009
October	0.009
November	0.009
December	<0.006

Concentration limit—0.04 pCi/m^3

Water

In addition to regular water samples obtained from four reservoirs, nonroutine raw surface water samples were collected from a number of outlying streams and lakes along with vegetation samples. Results of alpha activity analyses are given in tables 4 and 5.

Table 4. Alpha activity in water collected from reservoirs in the vicinity of RFP and outlying surface waters July–December 1965

Reservoir	Average alpha concentration (pCi/liter)
Great Western	2.2
Standley	2.1
Baseline	2.5
Ralston	3.2
Raw surface waters (collected June 1965)	2.7

Table 5. Alpha activity in vegetation, calendar year 1965

Distance from plant	Number of samples	Average alpha concentration (pCi/kg dry weight)
<3 miles	58	72
3–18 miles	44	61

Recent coverage in *Radiological Health Data:*

Period	Issue
July 1962–June 1963	February 1964
July 1963–June 1964	December 1964
July–December 1964	June 1965
January–June 1965	December 1965

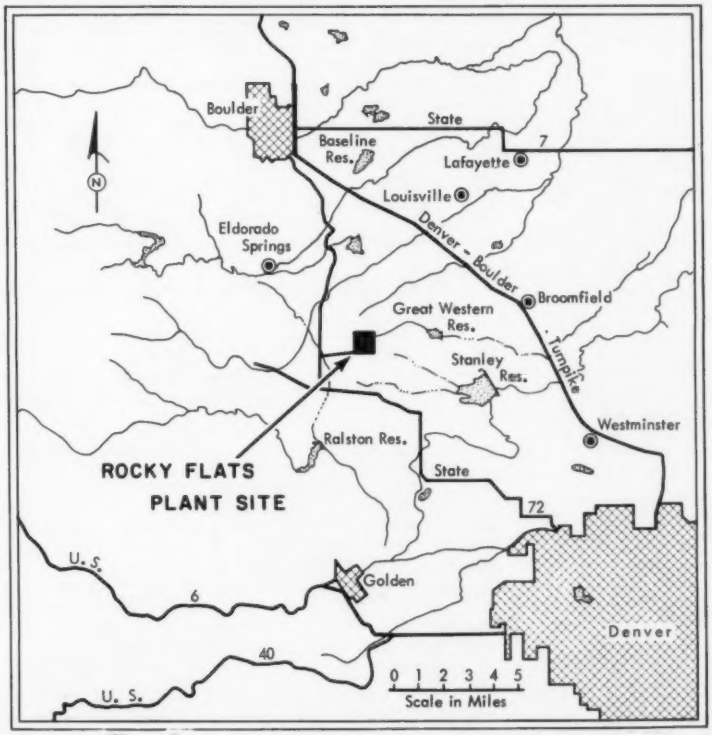

Figure 3. Location of the Rocky Flats Plant environment, Denver, Colorado

Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, MAY 1966

During May 1966, the Atomic Energy Commission announced seven underground nuclear tests at the Nevada Test Site. Tests conducted on May 4, 5, 12, and 27 were of low yield (equivalent to the force of less than 20 kilotons of TNT), and tests conducted on May 6, 13, and 19 were of low-intermediate yield (equivalent to the force of 20 to 200 kilotons of TNT).

Communist China's third nuclear explosion, occurring on May 9, 1966, was estimated to be in the lower end of the intermediate yield range (equivalent to the force of 200 kilotons to 1 megaton of TNT). Preliminary analyses of the debris from this test indicated that the device contained no plutonium but employed enriched uranium. Some lithium–6 was present, but its function is not clear.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

COLORADO DENTAL X-RAY MACHINE SURVEY, 1961–April 1965.

R. W. Alcox, R. A. Downs, and *P. W. Jacoe. Radiological Health Data and Reports, Vol. 7, June 1966, pp. 319–325.*

Results of a two-phase program for examining dental X-ray machines showed marked progress by the dental profession in correcting equipment and procedural deficiencies identified by mail-order surveys and physical surveys conducted by the Colorado State Department of Public Health. The first phase of the program was a "Surpak" mail-order survey and the second phase was a physical survey, using standards recommended by the U.S. Public Health Service for X-ray beam diameters, filtration of the primary beam, beam definiton, and leakage. Following the first phase of the study, the number of machines having beam diameters of 2.75 inches or less increased from 48 to 73 percent; following modifications during the physical survey phase, 85 percent of the machines met the standards. Improvement in meeting filtration standards is shown in a rise from 25 percent compliance during the first survey to 74 percent. During the physical survey, many areas of dental radiographic practice were examined and specific changes were made or recommended to minimize exposure to both patients and dental personnel. The most common procedural errors observed were overexposure and inadequate development of film.

KEY WORDS: collimation, Colorado, dental, development, equipment, exposure, film, filtration, standards, Surpak, survey, X-ray.

RADIOACTIVITY IN MILK IN THE UNITED KINGDOM, 1962–1965.

R. S. Bruce. Radiological Health Data and Reports, Vol. 7, June 1966. pp. 326–330.

Radiochemical analyses of raw milk produced in the United Kingdom showed that in 1962 the total iodine–131 in milk was about 85 percent of that found in the autumn of 1961; subsequently, levels have remained below the limit of detection. Concentrations of strontium–90 and cesium–137 increased sharply in 1962 and again in 1963, reaching maximum levels in the middle of the year. Since then, apart from seasonal fluctuations, there has been a general decrease in contamination. The annual average ratio of strontium–90 to calcium in milk in the United Kingdom increased from 5.9 pCi/g in 1961 to 28 pCi/g in 1964, and fill to 19 pCi/g in 1965. The mean concentration of cesium–137 changed similarly, the values for 1964 and 1965 being, respectively, 153 and 98 pCi/liter.

KEY WORDS: cesium–137, England, iodine–131, milk, strontium–90, survey, United Kingdom.

RADIONUCLIDES IN THE UNITED KINGDOM DIET, 1962–1964.

R. S. Bruce. Radiological Health Data and Reports, Vol. 7, June 1966, pp. 331–334.

In continuing United Kingdom diet studies, a fourfold increase in strontium–90 contamination of the average diet has been observed between 1961 and 1964. The ratio of strontium–90 to calcium in the average mixed diet in 1964 was 25.9 pCi/g (corresponding to an intake of 28.5 pCi/day), which is nearly three times the value in 1959. During 1962 to 1964, the relative contributions of strontium–90 from different types of food remained fairly constant. Cesium–137 levels increased markedly between 1961 and 1963, the estimated daily intake, based on assays of five types of food, rising from about 30 to 170 pCi/day; in 1964 the value was 160 pCi/day. Measurements of strontium–89 and barium–140 during 1962 and 1963 indicated that these nuclides were minor radioactive contaminants of the diet.

KEY WORDS: barium–140, cereals, cesium–137, cheese, eggs, flour, meats, milk, strontium–89, strontium–90, survey, tea, United Kingdom, vegetables, water.

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SYMBOLS, UNITS, AND EQUIVALENTS

Symbols	Units	Equivalents
BeV	billion electron volts	equals GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volts	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi per square meter (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi per square mile
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs per gram

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mī' kro
10^{-9}	nano	n	nā' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

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